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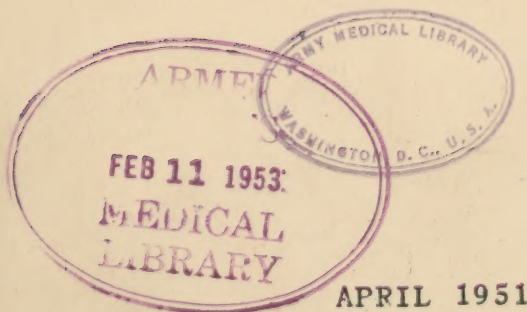
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ABSTRACTS OF ORTHOPEDIC SURGERY FOR 1948



OFFICE OF THE SURGEON GENERAL
DEPARTMENT OF THE ARMY
WASHINGTON, D.C.



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ABSTRACTS OF ORTHOPAEDIC SURGERY FOR 1948

U.S. Army Medical Dept. Orthopaedic Services

—EDITORIAL STAFF—

ABSTRACTS OF ORTHOPAEDIC
SURGERY FOR 1948

Prepared by the Orthopaedic Services

of

The Medical Department of the United States Army,

Department of Defense

Resident and Consultant Staff of the Orthopaedic Services of the
Hospitals of the United States Army

ADVISORY BOARD

Alfred H. Smith, Jr., M.D.

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ABSTRACTS OF ORTHOPAEDIC SURGERY FOR 1948

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P R E F A C E

The volume of Orthopedic literature has constantly increased over the years. The need for a condensation of this literature in the form of a ready reference is quite obvious, since few of us have the time to read all of the material published on this subject.

At the suggestion of Dr. A. R. Shands, Jr., Orthopedic surgeons of the military service undertook to review the Orthopedic literature of 1948. The Chiefs of the Orthopedic Services of all Army hospitals and their resident staffs have abstracted all articles pertaining to Orthopedics and closely allied subjects in English and foreign languages.

I wish to express my deep gratitude to all of the contributors who cooperated wholeheartedly and gave much of their valuable time to this work. I owe a debt of gratitude to Dr. Shands who has so ably prepared the material in final form for publication.

ORAL B. BOLIBAUGH
Colonel, Medical Corps
United States Army



CONTENTS

SECTION	PAGE
I Congenital Deformities	1
II Diseases of Growing and Adult Bone	20
III Tuberculosis of Bones and Joints	33
IV Infections of Bones and Joints	43
V Arthritis and Allied Conditions	57
VI Poliomyelitis	95
VII Neuromuscular Disorders Exclusive of Poliomyelitis	124
VIII Fractures	157
IX Fracture Deformities	196
X Tumors of Bones and Soft Tissue	205
XI Conditions of Lower Part of the Back	219
XII Conditions Involving the Thorax and Dorsal Spine	271
XIII Conditions Involving the Hip Joint	279
XIV Conditions Involving the Knee Joint	302
XV Conditions Involving the Foot and Ankle	311
XVI Conditions Involving the Shoulder and Neck	324
XVII Conditions Involving the Hand and Elbow	346
XVIII Amputations and Prostheses	364
XIX New Devices, Apparatus and Procedures	371
XX Research	387
XXI Miscellaneous Subjects	410
Subject Index	419
Author Index	430

FOREWORD

When it became evident, during the summer of 1949, that the Archives of Surgery would no longer publish the Progress of Orthopaedic Surgery in its present form, and that the American Academy of Orthopaedic Surgeons had decided to discontinue its preparation, the undersigned approached Colonel Floyd L. Wergeland, Chief of the Education and Training Division of the Office of the Surgeon General of the Army, concerning the Army Orthopaedic Services continuing the publication. Colonel Wergeland then held a conference with Colonel Joseph H. McNinch, Director of the Army Medical Library. It was decided that the preparation of this publication could be undertaken by the Orthopaedic Services of the Army Hospitals and would be made a part of the Army's training program. Colonel McNinch offered the full assistance of the facilities and staff of The Army Medical Library for this purpose and suggested that the "Current List of Medical Literature" Bulletins of the Library published each month be used as a source for titles.

Colonel Oral B. Bolibaugh was appointed by the Office of the Surgeon General to be Editor-in-Chief, and the titles for the abstracts from the 1948 literature taken from the "Current List of Medical Literature" were sent to a selected group of orthopaedic surgeons in the Army Hospitals. The abstracts were prepared by these orthopaedic surgeons, and the residents in the training programs with the assistance of some of the consultants, and were returned to Colonel Bolibaugh. In July, 1950, Colonel Bolibaugh became Chief of the Consultant Services to the Far Eastern Theatre and was unable to complete the preparation of the publication. In November, 1950, the abstracts were sent to the undersigned at the Alfred I. duPont Institute, Wilmington, Delaware, and in February, 1951, the Office of the Surgeon General decided to proceed with their publication.

After reviewing the material and deleting a few abstracts, it was thought advisable that, if possible, the remainder should be published in full and that the name of the publication should be changed to Orthopaedic Abstracts of 1948, since most of the abstracts did not represent progress or new information. These have been edited and put in final form for publication by the undersigned, and Colonel Knox Dunlap, Major Lucius C. Hollister, and Lieutenant Commander A. B. Dickson of the resident staff of the Institute.

These abstracts of 1150 or more articles by over 1400 authors represent a very complete review of the 1948 orthopaedic literature. The majority of the abstracts are excellent prepared; however, some are too long and some too short--but it is believed all have importance in teaching and research and will be of great value to orthopaedic surgeons and other physicians and medical workers desiring information from the orthopaedic literature of 1948. The undersigned is deeply grateful to the Army for the performance of this abstracts service and feels he is expressing the opinion of all physicians who may read the abstracts, when he says, "It is a job well done." The Army is publishing these for distribution to the Armed Forces Hospitals and medical installations, to medical school and hospital libraries and to interested orthopaedic surgeons and other physicians.

The undersigned wishes to express his particular thanks and appreciation to Colonel Oral B. Bolibaugh, the group of Army orthopaedic surgeons and all of the others who have labored long hours in the preparation of this material. He further wishes to thank Major General Raymond W. Bliss, the Surgeon General of the Army, Major General George E. Armstrong, the Deputy Surgeon General, and Colonel Floyd L. Wergeland, who have made this publication possible.

April 1951

A. R. Shands, Jr., M. D.
Advisory Editor

SECTION I

CONGENITAL DEFORMITIES

Part A. Prepared by Carl M. Rylander, Col., M.C., USA

Congenital Dislocation of the Hip

Steindler (1) discusses the development of present-day knowledge of congenital dislocation of the hip. He very briefly mentions various men and methods in the treatment of this condition. Congenital dislocation of the hip was first described by Hippocrates and then there was a period of silence for 2300 years. Dupuytren in 1826 was the first to give a good comprehensive picture of the condition in the modern sense. Sandifort, Hutton, Bouvier, Guerin, Parise, Lorenz, Putti, Paci and others contributed to our present-day knowledge. Putti gave us a technique of early reduction by the abduction method. In later years he considers that there are three definite additions to the treatment; (1) that early abduction treatment is the least traumatizing and therefore the most promising, (2) accurate concentric reduction of the head aids in the proper development of the acetabulum and (3) that prolonged after treatment for the development of the abductors and extensors is essential before weight-bearing is permitted. Open reduction has its value but it has limitations. Bost, Hagey, Schottstaedt, and Larsen (2) report on the results of treatment of congenital dislocation of the hip in infancy, based on 112 dislocations in 86 patients. They were observed over a period of from 1 to 13 years and were treated by several doctors so the methods were varied. As a rule they were reduced by the closed method of Denuce. Recently they have used traction first, where indicated, and this was done by the Coonse modification of the Putti method. Originally the fixation was obtained by plaster for about nine months. Recently they have used the abduction bar of Ponseti after about five months in casts, if the original treatment was in the first year of life. The classification of Severin was the one used in determining their results. The normal acetabular index of the newborn was 27.5 degrees and between 1 and 2 years of age it was 20 degrees, as determined by Kleinberg and Lieberman. In a few normal cases which the authors measured, it was from 12 to 28 degrees. The abnormal hips varied from 27.5 to 55 degrees, most of them being between 30 and 40 degrees. Fifty-one per cent of their cases had the acetabular index drop to 27.5 degrees in 3 years, decreasing more rapidly during the first year. Development of the acetabulum was greatest in those cases which had the least trauma in their treatment. Increase in the value of the Y coordinate might be due to a thickening of the floor of the acetabulum, soft tissue in the acetabulum or by maladaptation between the head and the acetabulum. Most of the cases with the Y coordinate of less than 7 cm. had good results and those with a value of more than 7 cm. had poorer results. A delay in the ossification of the head of the femur was always present. Aseptic necrosis was noted in 52% of the cases, being greater with the increase in the age at the time of treatment. Twelve per cent showed aseptic necrosis with treatment by abduction alone, 54% with traction and manipulation and 74% with manipulation alone. Good results decreased with the increase in age of the patient at the time of the first treatment.

Gill (3) reports a study of 105 cases of dislocations of the hip. The original treatment was that of "Bloodless reduction" and 52 of the cases were operated upon subsequently. Out of 289 cases which he had during this period of time, 27% were in females; 41% of the unilateral cases were on the right side; 26.9% were bilateral. The end results of the 53 cases treated without operation in the 105 cases were: perfect 16%, excellent 10.5%, satisfactory 14% and failures 10%. The total number of failures for both methods was 59%. Perfect, meant perfect function and anatomy; excellent indicated perfect function but slight deformity in the anatomy; satisfactory indicated perfect function but rather marked changes anatomically. Failure indicated a recurrence of the luxation or subluxation. Many of these cases were improving and he felt that eventually some of them could be placed in the next higher classification. Some of the operations were done a long period of time after the original reduction, some as long as 20 years. Getting a child before 3 years of age is important but it is more important to reduce the hip soon after the dislocation. A child who does not develop the dislocation before the age of walking will do better than one who had the dislocation at birth but did not have the reduction until the age of walking. Ninety-four per cent of predislocations treated by abduction gave satisfactory results but there are other factors which are present which affect the results. Genetic or mechanical factors may alter the results as may also constitutional or physiological conditions of the mother. Dysplasia or aplasia of the acetabular roof, if not associated with other structural defects of the hip offers the best prognosis for a normal hip with treatment. Aplasia of the femoral head is more resistant to treatment and gives poorer results. This latter condition is what some people call a Perthes disease but Gill feels that this is not a true Perthes. Other severe deformities which prevent complete bloodless reduction are; inequality of the head and acetabulum, deformities of the head, capsular constriction, shortness of the neck and high insertion of the capsule on the femur. Most or all dislocations have some degree of anteversion but most of these can be reduced and held in internal rotation. If they do not hold, then there are probably some other defects which need correction. He thinks that this tends to correct itself but some require osteotomy.

In his conclusions Gill states that 25% of cases of dislocated hips become perfect or excellent and this is increased to 35% if treated before the age of 3 years. Fifteen per cent become satisfactory and 20% if treated before the age of 3 years. Failures come in about 60% of the cases but 45% if treated before the age of three years. The form and degree of dysplasia and the ability of the child to resume normal growth are the main factors determining the end results.

Crego and Schwartzman (4) report a follow-up study of 93 cases of congenital dislocations which have been observed since 1937. Sixty-one of these were posterior dislocations, 17 were upward luxations or subluxations and 15 reported elsewhere were anterior dislocations. They were followed for from 1-15 years, 50% being observed for 6 years or more. These cases were treated by traction first to bring them down into proper position and then held in that position for four weeks. The head could then be easily replaced into the acetabulum by internal rotation and abduction. They

were then held in plaster for about three months. A few of the cases could be reduced by gentle manipulation only, without traction but very little force was used. Most of the cases required traction by skeletal method. All cases could be brought down by traction but only 55% could be seated stably as the only initial treatment. In only 14% could stable reduction be maintained. Eighty-five per cent required correction of other abnormalities for stable reduction to be maintained. For the correction of the dislocation they had to consider (1) the dislocation itself, (2) anomalies of the head and neck of the femur, (3) anomalies of the capsule, and (4) anomalies of the acetabulum. Absence or partial absence of the head and neck, they felt, was not amenable to this type of treatment and in these they did some type of pelvic support osteotomy. Femoral torsion was present in 71 cases. This was determined by getting AP x-rays with the knees in the neutral position and one in internal rotation. Sixty-seven supracondylar osteotomies were done and five of these were redone. They were done after the three months of plaster immobilization; threaded wires were inserted into the upper fragment which was held in internal rotation, while the lower portion was rotated externally. They were then kept in casts for two more months. Capsular anomalies may be found where the capsule has an hour-glass constriction. Some of these can still be reduced but the head is not well in the acetabulum but at the end of three months of plaster it is well in place. Some however are too far out and an open operation is done and this deformity is found. The acetabulum is filled with fatty tissue and pannus, and this is removed. Acetabular inadequacy is found in almost all the cases but about 50% develop with treatment. The others required operation and if the head did not remain in place after the capsule had been opened and the acetabulum cleaned out, then an acetabuloplasty was done, that is levering the superior acetabular rim down and holding it in place with bone above it. There were forty of these reconstructions done. These hips were graded as normal, near normal, satisfactory and failures. Ninety-two per cent fall in the first three groups and 8% were failures. No evidence of Perthes disease was seen with this treatment but did occur with the more forceful reductions done previously.

Frankel (5) reports on the results of treatment of irreducible congenital dislocation of the hip by arthrodesis. He studied 14 cases of arthrodesis of the hip but was able to follow only 8 of these. They were 8-15 years old. Four cases had initial extra-articular fusions in which tibial or trochanteric grafts were driven through the head distally into the ilium. One required a secondary extra-articular fusion. In two cases no graft was used and one of them did not fuse. The average fusion time was two years, some in 11 months, and one up to 38 months. Prior to surgery the shortening was 3-1/5 inches and after surgery it was 3/4th inches. He used traction prior to surgery for three to eight weeks. He feels that the operation should be limited to those of the lower economic level, those who will be most likely to do some type of standing work. This gives the best hip as far as fatigue and pain is concerned.

McCarroll (6) has found anterior dislocation in 22.5% of all congenital dislocations. He originally used traction, closed reduction and then open reduction and a superimposed massive anterior shelf. Longer observation of these cases showed that 5 were fair and six were poor with one good. Since then he has been able to do a closed reduction with success in 5 cases (20%) and has had good results with these. Five cases had an acetabular reconstruc-

tion and after 3.6 years one was good, 3 fair and one poor. One case had the acetabulum deepened with fair results. He feels that the basis underlying anomaly in the primary anterior dislocation is a defect in the anterior acetabular rim. He has tried a large anterior buttress of iliac bone in the anterior rim of the acetabulum, first outside the capsule and later inside the capsule. Final results of these are not yet available.

Leveuf (7) distinguishes between luxation and subluxation. In luxation there is always interposition of soft tissue between the head and the acetabulum. There is an hour glass constriction of the capsule; a cartilaginous roof pushed down into the joint by the head. The head of the femur is small. The ligamentum teres is huge. The acetabulum is fair sized when the soft tissue is removed. In subluxation there is no soft tissue interposed. The limbus is pushed against the acetabulum. The acetabulum assumes an oval shape. The head is large and out of shape. These findings are shown by arthrography. In true luxation closed reduction is not possible. In his open reductions he finds that their readings of the arthrograms were correct. Those cases that failed in closed reduction, showed that there was soft tissue interposed at operation. The results in 116 cases of primary open reduction were given. Eighty-five per cent were well replaced. The head was changed by epiphysitis postoperatively in some of the cases, 23%, and of these 12% were severe with permanent change in the head. The ligamentum teres was present in about half the cases. When it was cut, there was epiphysitis in 47% but when there was no ligamentum teres there was epiphysitis in only 16%. The ligamentum teres did not bleed when cut except in young infants, under two years. There were 81.9% with perfect or good results, that is flexion to 90° and abduction to 45%. The best results were obtained in children under 3 years of age but since most of the epiphysitis cases occurred early, he did not operate normally under two years. The results after open reduction with shortening of the femur; of 95 dislocations, 81 were in children between 3 and 15 years and the others older than this. Fourteen showed perfect results, 16 good, 43 poor and 8 bad. He advocated operation in adults only in unilateral cases, in order to give the head a stable place to rest but little movement was obtained. Operation after reluxation did not give good results but he felt that they were sufficiently good to warrant operation.

Denis Browne (8) assumes that the hip is dislocated in intra-uterine life by a thrust on the knee, in flexion, pushing it out posteriorly and because of this, he believes that reduction should be done in the opposite manner. Active movements of the hip in the acetabulum should have good effects. The head can leave the acetabulum only backwards. Because of the ilio-femoral band, it can go backwards only with the knee flexed, therefore movements are permissible as long as the knee is kept back.

In attempting reduction, the child is placed on his face and the affected hip brought into the fetal position. The heel of the surgeon's hand is applied to the greater trochanter, posteriorly, and he pushes forward. With the other hand he moves the knee up and down through a very small angle. He gets a crunching feeling when the head slips back into the acetabulum. A cast is then applied in this position and left for one month. The knee is included in the cast on the affected side. At the end of this time he applies a ring of metal over each thigh and these two rings are con-

nected by a metal bar which is held in place by a soft belt. The position as shown in a diagram is that of the usual frog position, with the thighs in full abduction and external rotation. They are then allowed to be around as they choose, on their hands and feet; or on their feet with the knees flexed and their buttocks near the floor or semi flexed position with knees widely separated. They are removed from this on x-ray evidence, but most of them are held for a period of 9 months. If the hip slips out during the treatment, the whole procedure is started again. The author states that he has treated 42 cases in this manner and all had stable painless hips. In three cases he did an open reduction, cut the ilio-femoral band and then continued the treatment as above, with good results.

Other Deformities.

Wilson (9) discusses congenital anomalies requiring early recognition and immediate treatment. He lists a number of conditions other than orthopedic, which should be recognized early and should be operated or treated early for best results. If the first child of parents has defects, the second is more likely to have some, than is the child of other parents. Those with one deformity are also likely to have other deformities. Spina bifida occurs fairly frequently. A few cases are anteriorly and little can be done for them. They frequently have hair and pigmentation of the skin over the lower lumbar and sacral area. With a meningocele, the meninges alone are involved and in the cystic cases 80-90% die in one year without operation. Myelocoele has no sac and operation is not of much help. With complete paralysis, do not operate.

Wolman (10) reports on 37 cases of Erb's palsy. This type of palsy is confined to muscles supplied by the 5th and 6th cervical nerves. In severe cases it involves the deltoid, supra- and infra-spinatus, teres minor, biceps, brachialis, brachio-radialis and supinator muscles. It gives a characteristic deformity, the arm hanging limp at the side, elbow extended, and hand and arm rotated medially so that the hand faces posteriorly. There are no sensory changes. It is due to the stretching of the supra-clavicular portion of the brachial plexus during birth. A few more cases have been reported in males than females and a few more on the left than on the right side. Fifty-four of 125 cases were in primigravida. Thirty-four cases were breech deliveries. Forty-seven cases were forceps deliveries in the vertex presentation and 11 in the breech presentation. All but 5 of the cases weighed $8\frac{1}{2}$ pounds or more. Treatment consists in placing the arm in a light metal splint with the arm in abduction and external rotation, the elbow flexed to 90° and the forearm supinated. Exercises are given by hanging colored balls over the crib. The author also gives massage and passive exercises. Treatment should begin early, preferably before the end of the first month. Those cases which he was able to follow, showed excellent results if started early. If delayed, the final results were much poorer. Surgery is not recommended.

Gray (11) described the dissected specimen of an amputated leg in a three year old boy with congenital absence of the tibia, as well as an absence of the talus, navicular, three cuneiforms, two medial metatarsals and three medial toes. He also had absence of some of the muscles of the leg. The deficiency of the tibia may be complete or partial and if the latter, the lower end is absent. There may be just a fibrous cord representing the

tibia. Other congenital abnormalities are frequently present. In these cases, the mother's health is usually reported as good during her pregnancy. There is usually no family history of congenital abnormalities. Two cases were reported, however, in which the father and son both had absence of the tibia. The cause of this condition is not known. The author suggests that the defect is due to failure of differentiation of the blastema of the tibial anlage. He thinks that this condition can be induced in the embryo if it is exposed to harmful environment at the appropriate stage of development.

Jebens (12) discusses congenital dislocation of the shoulder as seen in a 16 year old girl. Some abnormality of the right shoulder was noticed a few days after birth and she was treated in the hospital for a few weeks in an abduction splint. Her father and three brothers had severe deformities of their hands and feet. She had considerable limitation of motion of her arm. X-rays showed a deformed humeral head in backward dislocation. The glenoid was rudimentary. The acromion arched downward and the coracoid process was greatly elongated. Only 21 cases had been reported at the time.

According to Baker (13) metatarsus varus is quite common in children but it is often minor and usually corrects itself. It is most noticeable when they begin to walk. With it they usually have an overactive abductor hallucis. This condition is frequently missed by the pediatrician until the infant begins to walk. The author discusses the structure of the foot and its evolution from the primitive mammalian foot. He also discusses the weight which is placed on various parts of the foot on walking. The first metatarsal is of special importance as it supports the medial side of the foot, and prevents depression of the sustentaculum tali; it supports the major share of the static stress in locomotion, and it gives support to the talus. Certain deviations from the normal which are inherited and represent a failure of full development can result in foot strain: 1. Short first metatarsal; 2. Posteriorly placed sesamoids under the first metatarsal; 3. Hypermobility of the first metatarsal; 4. Metatarsus varus; 5. Short heel cord. Metatarsus varus does exist in adults as seen by x-rays but is often difficult to diagnose without the x-rays. The author prefers to treat the metatarsus varus by applying casts in some correction, and at the end of one week, wedge the cast at the tarso-metatarsal area. At the end of the second week, a new cast is applied and the procedure is repeated. This is continued until correction is obtained. This may require months of treatment. At the end of this time, corrective shoes should probably be worn. Milder cases, can, at times, be corrected by stretching, several times per day.

Lucas, (14), reports on surgical procedures in the treatment of chronic clubfoot, based on the treatment of 321 cases. Cases treated by conservative treatment only, were not included. He advised the Kite cast method of treatment as the best for general use. One must have a thorough knowledge of all the factors involved before starting the treatment of a case. Inform the parents of the possibility of recurrence. Make frequent checks of the patient for several years, even after operative correction. They should have a balance of their muscles. Soft tissue surgery may be all that is necessary but it should be followed by supervised physical therapy. Achilles tendon lengthening may be necessary if unable to get the correction by manipulation and casts, but should be done only after the forefoot and tarsal varus has been corrected. Posterior capsulotomy may be necessary. A persistent deformity that may persist is a cavus foot. If this does not

correct with gentle manipulation, then you may do a plantar fasciotomy. He prefers a lateral approach for this operation as there is less danger of damage to the vessels and nerves. If there is contraction of the scar, after the wound has healed, this scar will then tend to preserve the correction. Exercises and stretchings are continued following surgery. With weak peroneals and a strong anterior tibial muscle, he transplants the anterior tibial tendon to the anterior or antero-lateral portion of the dorsum of the foot. The tendon should be well anchored in bone. He uses an operation devised by Dillehunt. An incision is made from the heel forward, under the medial malleolus up to the first metatarsal joint. The posterior capsule and deltoid ligament are cut and the Achilles tendon is lengthened. At times, he lengthens the posterior tibial tendon, cuts the subastragalar; astragaloscaphoid and scaphocuneiform capsules and ligaments. Care should be taken not to injure the cartilage of the joints. Casts are then applied in as much correction as the patient will tolerate. Change the cast in three weeks and get the full correction at that time. Circulation may be so embarrassed with this that it is necessary to check it carefully. If one is unable to get correction of the varus of the calcaneus, then do an osteotomy on the lateral side, using a notch in it to prevent it from slipping back. In obstinate cases, do a triple arthrodesis. In this operation, the bones should be made to fit together accurately. The author feels that tibial torsion is a factor in maintenance of the deformity but this usually disappears after the foot is corrected. If it persists he does an osteotomy at the upper end of the tibia, making it notched, so that it will not slip. The fibula is not cut. He advocates the mildest form of treatment which will give correction.

Goldenberg (15) states that in the available literature, there is no report of congenital bilateral complete absence of the radius in twins. He shows radiographs of two boys who were born in 1938 with this condition. They were operated upon in 1947, at which time the end of the ulna was split and the radial half inserted into a notch between the 2nd and 3rd metacarpals. The left side was successful but the right failed, having an absorption of the graft in both patients. The left side gave considerable improvement in the condition of the hand.

Rampoldi (16) analyzes the findings through three generations of congenital hip dislocation occurring in one family. The male in the first generation showed a deformity of the sacrum by radiological examination. The second generation consisted of 11 individuals, all but two of whom showed some congenital deformity. Two females presented shallow acetabula, one male showed a deformity of the sacrum, four females had congenital dislocations of the hip and in two patients there was coxa valga. The third generation consists of twelve individuals none of whom shows any deformity except for one male who presented a coxa valga. The author concludes that the deformities show recessive rather than dominant characteristics.

Part B. Prepared by Sterling T. Ritchey, Lt. Col., M. C., U. S. A.

Realizing that the greatest number of congenital deformities appear in the first eight weeks of prenatal life which is the period of the greatest fetal growth rate, MacLean (17) classifies the cause of congenital deformities as those due to: 1. genetic factors (mutations due to radiation, chemicals, and somatic causes) and 2. environmental factors (such as nutritional, chemical, endocrine, actinic, infectious, and mechanical). The controversial somatic genetic theory postulates that during embryonic development a mutation occurs in one cell which thereafter is transmitted only to the descendants of that cell. In early stages of division then, this would involve large segments of the final fetus. For instance if it occurred in the first division stage it would result in changes in half of the fully developed body. The author lists deformities inherited by the dominant mode such as brachydactylism, polydactylism, syndactylism, cleidocranial dyostosis, multiple exostoses, achondroplasia, and those inherited by the recessive mode, i.e., polydactylism, spina bifida, congenital dislocation of the hip.

The environmental factors that adversely affect the embryo in early developmental life are many. Nutrition of the ova as affected by its own connection to the maternal host has been repeatedly proven to be related to congenital deformities. Measles in the first trimester may alter the environment of the eye by resultant vascular changes resulting in cataract. Local effects on the embryo by starvation of the maternal host are more than probable and certain dietary deficiencies have been proven to cause developmental defects of the fetus. This has been repeatedly proven by animal experiments. Lack of copper in the diet of the sheep uniformly results in paralysis of the hind extremities of the offspring. Iodine deficient diets in sows uniformly result in deformities of the offspring such as brittle hooves and patent foramen ovale and these deformities are prevented by the feeding of iodine. The well known endemic effects of lack of iodine in the human diet and the resultant cretinism is cited. In swine the lack of vitamin A results in sterility, fetal death, weak offspring, blindness and other miscellaneous defects. These changes are reversed in subsequent litters by the feeding of Vitamin A. Rats fed upon a riboflavin deficient diet gave birth to litters, one-third of which had congenital skeletal defects and again this pattern was reversed by the feeding of riboflavin in subsequent pregnancies. Lack of Vitamin D in the human has been well known to cause congenital rickets.

The effects of chemicals upon the embryo have been proven experimentally with fish, and the pattern of the defect created is dependent upon the time at which the injury was inflicted rather than the type of chemical used. It is quite probable that there is an effect of endocrine influence upon the developing embryo. The pregnant rat given androgen results in a depression of the female sexual characteristics of the offspring and the administration of estrogen inhibits the male sexual characteristics and results in overdevelopment of the female sexual organs.

Insulin probably has some effect upon the embryo, as diabetic mothers can expect to have a higher fetal mortality rate and this is definitely reduced by the use of insulin. The effect of irradiation of the developing embryo has been proven beyond doubt, but margins of safety and the remote and subsequent generation defects have not been firmly established. The infectious factors influencing the embryo are well established by the known effects of measles during the first trimester of pregnancy. There is strong likelihood of the child of a mother who has suffered measles during the first two months of her pregnancy to be born with congenital cataracts, congenital heart disease and other miscellaneous defects. In one series of eleven cases of mongolism nine were associated with a maternal infection during the second or third month of pregnancy and it is commonly believed that mongolism is not the result of maternal endocrine factors.

Certain mechanical factors still are related to congenital defects. This cause is related to scanty amniotic fluid and amniotic bands and is characterized by pressure marks on the infant and points of pressure atrophy over bony protuberances.

Stevens (18) reports identical twins, age twelve, both with congenital torticollis as the first such case report known. The birth history was not obtainable, the mother was not living. Both twins had identical, right torticollis with no palpable mass. One twin had a convergent squint of 15° which was not considered related to the torticollis by the ophthalmology consultant. They were treated by sectioning of the sterno-cleido-mastoid muscle and fascia and recovery was normal; neck movements with normal range were present five months postoperatively.

(Ed. note: This report adds weight to the congenital etiology of muscular torticollis.)

Caffey (19) describes prenatal bowing and thickening of tubular bones, with multiple cutaneous dimples in arms and legs which is a congenital syndrome of mechanical origin. A small number of cases of this type have been reported in the literature to date. The author reports on three cases with symmetrical bowing of the femoral and humeral shafts but with asymmetrical deformities of the shafts of the tibia, radius and ulna. The shafts of these bones were thickened and bowed at the middle third. Large cutaneous dimples were present over the crest of the bowing in two cases which Dennis Browne in 1936 stated were intrauterine pressure necrosis points. These were present at the end of the follow-up periods of 24 and 30 months. The author believes that these three cases were the result of faulty intrauterine pressure and supports this hypothesis by pointing out that the children were entirely healthy but for these deformities. All came from normal families; there was no evidence of generalized or localized skeletal disease, and the bowing was characterized by thickening of cortex on the concave side of the curve. All cases improved spontaneously. However an osteotomy was performed on the tibia of the third case which was followed for a period of seven years.

Nachlas (20) discusses common defects of the lower extremity in infants. The lower extremities of the newborn differ in their bony relations from the adult. The main points of differences are lateral bowing

of the legs, external rotation and flexion of the hips, and internal rotation of the legs and feet. The neck of the femur is at a more obtuse angle with the shaft. The stimulus of function associated with growth finally evolves the normal adult pattern. Any delay in growth or function such as delayed walking from one cause or another will result in delayed development of the adult pattern. One or many components of these infantile patterns may persist such as hallux varus, metatarsus varus, equinovarus, or internal rotation of the leg. External rotation deformities are the result of contractures and developmental defects. The author recommends corrective shoes and corrective adhesive tape for hallux varus deformities, and states that metatarsus varus may be overcome by manipulative stretching, the wearing of clubfoot shoes, rarely resorting to manipulation and casting. The treatment of the congenital clubfoot requires specialized treatment and should be referred to an orthopedist for care. The author states that an internal rotation deformity of tibia may be corrected by repeated daily derotation manipulation. A child may walk with a clubfoot gait which is the result of stretched and painful medial foot ligaments which may be detected by the presence of tenderness and pain on attempted correction. This deformity is better treated by over-production of the deformity, the foot being held in inversion for a week or two. A knock knee with strained medial ligaments at the knee will also cause the child to walk in internal rotation as a protective mechanism.

The outward rotation deformities are commonly seen as a congenital calcaneo-valgus. This deformity the author treats by adhesive tape correction, rarely resorting to plaster casts. Occasionally an infant is seen which presents external rotation and flexion at the hip, the result of contraction of the external hip rotators. This deformity responds well to daily manipulative stretchings. The flat foot seen in the young child is usually the flexible type and is occasionally due to a short tendo Achillis after ambulation has begun. Inner shoe wedges are usually successful, occasionally an arch support needs to be added. The flat foot which is associated with knock knee is treated by manipulation, inner shoe wedges and occasionally braces.

Clarke (21) discusses briefly the usual clinical patterns of osteogenesis imperfecta tarda (Lobstein's disease) and presents a case report. The parents stated that they had noticed clicking in the child's lower extremity joints since the age of eight months. They brought the child to the doctor when she failed to stand at twenty-two months of age. There was no familial history of brittle bones but the mother had blue sclera and was deaf. The brothers of the patient's mother and in turn her mother were all deaf and some of these had the onset of their deafness in early adult life. The physical examination revealed blue sclera, eroded teeth, the typical cranial deformity and marked laxity of the lower extremity joints. She was walking in braces. All clinical laboratory tests were negative. There was no history of fractures. In the author's discussion he points out the clinical and x-ray changes typical of this disease. He discusses the x-ray changes of the skeleton, the changes of the skull and face, i.e., the broad temples, and the pointing outwards of the upper portion of the ears, which result in a small triangular shaped face. Blue sclera is apparently another inherited

characteristic but not necessarily associated with brittle bones. Deafness is due to otosclerosis appearing in early adult life when bone fragility is replaced by bone sclerosis.

Giannini, Horreelli, and Greenberg (22) report a four and one-half year old Puerto Rican boy of dwarf stature due to an incomplete number of vertebral segments and a faulty development of the vertebral column. The mother had been treated for syphilis but repeated serological tests on the child were negative. X-ray studies of the boy revealed a normal skull and long bones. There was slight variation of contour of cervical vertebrae. There were only eight thoracic vertebrae with multiple abnormalities. There were seven ribs on one side, eight on the other, with a right dorsal scoliosis. The lumbar spine was normal with slight variations but there were only three sacral centers present. The family history revealed no similar deformities. The authors present this abnormality as another cause of dwarfism.

Wrist drop in the newborn due to radial nerve paralysis is rare. Wrist drop due to a fixed flexed posture of the wrist in utero is not too uncommon. Morgan (23) reports three cases, two due to nerve paralysis, one due to posture. The first case was in an infant delivered after a difficult four day labor which was terminated by forceps. The infant on delivery presented a depressed pressure ring around the trunk and both upper arms with ecchymoses. The child was treated with cock-up wrist splints and there was return of radial nerve function in eight days; full recovery was present at the end of three months. The pressure constriction ring about the lateral surface of both upper arms required three months to return to normal. The second case was unilateral and was present in an infant delivered by forceps. The patient had an obstetrical fracture of the humerus. Treatment consisted of splinting of the extremity with the elbow in flexion. One week following delivery a radial nerve paralysis developed and a cock-up wrist splint was added. There was beginning return of function in three days and there was complete recovery in seventeen days. The third case was also delivered by forceps with a positional wrist drop. The elbow, wrist and fingers were flexed, the forearm pronated, and the hand fitted into a depression behind the ear. Treatment consisted of cock-up wrist splint. The fingers extended at one week and the patient was fully recovered at the first postnatal visit.

MacFarland (24) discusses the less common orthopedic congenital defects. The tibia is more often absent than the fibula. If the tibia is absent the fibula is usually rudimentary and the foot defective, although the tibial elements may be present. The treatment is amputation and it is advised to amputate after the child has established walking habits in a temporary prosthesis, amputation being deferred until after the third year.

In congenital synostosis of the radius and ulna, the forearm is usually fixed in moderate pronation although the position may be one less satisfactory for functional purposes. The synostosis usually occurs at the upper portion of the shafts. Surgery is generally unsuccessful because of associated soft tissue changes. Successful resection of the

synostosis is not usually followed by satisfactory supination and pronation. The child usually compensates very well for the deformity; however if pronation is severe, an osteotomy is indicated to place the arm in a more functional position.

In congenital lobster claw hand, two digits only are present, one resembling a thumb and the cleft extends to the carpals. The fingers usually are not straight but they conform to each other in apposition and palmar skin is present on the opposing surfaces. Surgery can offer no improvement in function.

In congenital dorsal adduction of the 5th toes, these toes overlapping the neighboring 4th toes, lead to difficulty in shoe fitting and maceration of the skin between the toes. Amputation through the metatarsophalangeal joint is recommended.

In congenital elevation of the scapula, there is a variable degree of deformity. There may be a very high or cervical scapula fixed with an omovertebral bone, with tilting of the head, and limitation of motion in the shoulder and neck. Surgery is disappointing. It is better reserved for the severe deformities and the recommended procedure is that of resection of the scapula. The milder cases improve with repeated stretchings and supervised active exercises.

Brandt (25) presents a case of arthrogryposis multiplex congenita anatomically appearing as a foetal spinal muscular atrophy. This congenital disease was first described by Guerin in 1880. There followed several case reports between 1901 and 1937 in most instances described as multiple congenital contractures. In 1923 Stern renamed the deformity arthrogryposis multiplex congenita. Typically all four extremities are involved. The usual contractures are internal rotation of the shoulder, extension of the elbow, pronation of the forearm, flexion of the wrist, and flexion with ulnar deviation of fingers. The lower extremities commonly present flexion and external rotation of the hips, extension or hyperextension of the knees and severe varus or equinovarus of the feet. Complete ankylosis of the joints is rare, the limitation being due to the contracture of the joint capsule and ligaments. The active range of motion of the joints affected is decreased due to these contractures and to muscle changes most commonly affecting the deltoid and deep shoulder muscles, flexors of the thigh, flexors of forearm, and extensors of the fingers and wrist. The muscle changes are essentially those of atrophy, fibrosis, and shortening. Luxation of joints is common. Other deformities may be present and sometimes only the upper or the lower extremities are involved. The skeleton is usually normal, however, there may be an absence of the patella if the knee deformity is severe. The intellect is unimpaired. The child is frequently delivered abnormally because of the fixed abnormal position of the extremities. Occasionally a history of faint fetal movements is obtained. In 47 collected cases, 25 were males, 22 females.

The author presents a case of arthrogryposis which is the second case reported with post mortem studies of the central nervous system. The first case was reported by Price in 1933 who found evidence of inflammation and degeneration of the central nervous system and concluded that there

was an infectious etiology. The author's case is a three week old male infant who nursed ineffectively and when first seen, was markedly undernourished and dehydrated. There was internal rotation of the shoulders, pronation of the forearms, extension of the elbows, flexion of the wrists, with ulnar deviation and fixation of the thumbs in the palms. No passive correction was possible. Marked muscle atrophy was present; the latissimus dorsi was short and tight on both sides and the shoulders could be abducted to only 45 degrees. The hips were flexed and abducted, the knees flexed and there was varus deformity of the feet. There were no palpable dorsal spine muscles, there was atrophy of the cervical spine muscles and there was a fixed opisthotonus posture contracture. The facial muscles were atrophied, the child could not close his mouth. The eye and tongue muscles functioned normally. The x-rays revealed no skeletal defects. Laboratory tests were all normal and the infant was judged normally intelligent.

The child died at the age of seven weeks and post mortem examination revealed no abnormalities of the visceral organs. Biopsy of the quadriceps muscle revealed considerable increase of fascicular connective tissue, extreme atrophy of the muscle cells which were seen as areas rich in nuclei with degenerated threads of muscle tissue. No inflammatory areas were discovered or areas of vascular changes. There was no evidence of muscle degenerative changes. Studies of the central nervous system revealed lower motor neuron degenerative changes. There were profound changes seen in the anterior horn cells with severe degeneration of the cells with sclerosis and vacuolation, and numerous empty spaces previously occupied by motor cells. There were scattered normal cells seen throughout the tissue. The histological diagnosis was a degenerative central nervous system lesion, with secondary muscle changes.

The author postulates the etiology of arthrogryposis, based upon this study, to be a lower motor neuron degenerative disease occurring early in fetal life. He reasons that the paralysis occurring early in fetal life before the muscles are active enough to move the various affected joints accounts for the severe contractures present. This pathology he holds to be allied to the Werdnig-Hoffman's spinal muscular atrophy which he believes occurs later in fetal life after fetal motion is active and range of motion at the joints is thus actively established before the onset of the paralysis. Other etiological theories are comprehensively discussed.

(Ed. note: This is a well presented study of this comparatively uncommon though severely crippling congenital deformity. The author's deductions as to etiology are logical and it is hoped that this report will offer further stimulus to additional studies of post mortem material. It is possible that more careful prenatal histories will disclose the relationship of this disease to prenatal maternal infections.)

Sear (26) reports a case of Engelmann's disease; osteopathia hyperostotica sclerotisans multiplex infantilis. This is the rarest form of the congenital condensing osteodystrophies. The case reported represents the second appearing in the literature at the time of publication. A ten year old boy presented x-ray evidence of symmetrical bone condensation mainly at the central portions of the shafts of the long bones associated with thickening. This was the characteristic change in the case reported

by Engelmann in 1929. The bone changes were more marked in the clavicles, forearm bones, femora, and tibiae. There was also condensation of the basilar skull and frontal bone associated with thickening and in addition an area of condensation in the iliac bones and the first cervical vertebrae. Clinical laboratory tests were normal but for slight hypocalcemia. Biopsy studies were inconclusive.

Andreasen (27) reports two cases of congenital absence of the humeral head, one unilateral and one bilateral. Radiographs and photographs are shown. There was limitation of abduction and rotation at the shoulder. Review of the literature revealed six other reported cases. The author discusses the embryological aspects of this deformity concluding the defect to be the result of a developmental accident occurring at the stage of separation of the articular rudiments during embryological development.

Vastine II, Vastine and Arango (28) report myositis ossificans progressiva in homozygotic twins. This represents the first reported case of myositis ossificans occurring in identical twins and lends weight to the genetic etiological theory of this condition. The authors briefly discuss the other evidence of the hereditary nature of this disease and point out that the condition is an ossification of connective tissue rather than muscle tissue. They also discuss the clinical manifestations, x-ray changes, and pathology of the disease. The twin girls were ten years of age when first seen, complaining of stiff neck and stiffness in other joints. Both had well advanced manifestations at this time, with limitation of motion of the cervical spine, and upper extremity joints; both had short left great toes. The family history was negative. Both girls were studied roentgenologically at the age of sixteen, revealing a similar pattern of ossification of soft tissues in the posterior cervical region, posterior thoracic region, along the lumbar muscles, and about the hips. In addition there was found to be fusion of the great toe phalanges and deformity of the distal heads of the first metatarsals.

Gordon, Schechter, Perlman (29) report a case with multiple congenital deformities. The case is presented as having congenital skeletal deformities not previously related in any clinical syndrome. A thirteen year old white female with no familial history of deformities had been treated since the age of fourteen months with thyroid extract. The outstanding skeletal changes discovered were multiple luxations, involving both patellae and both radio-humeral joints, and multiple fusions of the small bones, and of the cervical, and lumbar vertebrae.

The case of a thirty-seven year old male with flattening of the base of the skull, vertebral chondrodystrophy and osteoporosis and many other changes is reported by Hajdu, and Kauntze (30). There was no family history of deformities. The skull was clinically broadened with decrease of the vertical height and flattening. The palate was high and narrow, the jaw prominent and the neck was short. He had a moderate valgus deformity of both knees and elbows and the fingers were short and bulbous. Conduction deafness was present. Clinical laboratory tests were within normal limits. X-ray studies revealed a marked basilar impression with broadening of the skull, patent suture lines and small facial bones. The vertebral bodies were osteoporotic and biconcave with collapse and scoliosis

resulting. The terminal phalanges of the fingers were represented by a visible proximal epiphysis and the visible tip of the shortened phalanx. There was also some deformity of the metacarpal heads, radio-carpal articulations, carpal bones, distal portions of the forearm bones, and severe osteoporosis of the phalanges of the right foot with findings of the terminal phalanges resembling those of the fingers. The authors conclude that the peripheral lesions are the result of failure of ossification of pre-formed cartilage. The vertebral osteoporosis is not explained.

DeVito (31) reports a case of osteogenesis imperfecta in a seventeen day old white male who was brought to medical attention because of bowing of the legs and softness of the cranium noticed by the parents. The prenatal and delivery history were normal and the child's general condition was good. The family history was negative. Physical examination revealed softening of the cranium, most marked over the occipital area, and widely opened sutures. There was a blue tinge to the sclera. The anterior borders of both tibiae were irregular. X-ray studies revealed deficient calcification of the skull and bulging fontanelles. There was a tendency of the cervical spine to prolapse into the skull. The spinous process of C-2 was fractured along with evidence of fractures of an acromial process, scapula, femur and ulna. There was congenital dislocation of both hips, bilateral clubfoot deformity, anterior bowing of both lower extremities and multiple fractures of the ribs with deformity. The patient was discharged from the hospital and died suddenly twenty-four hours later of an acute atelectasis. At autopsy the following pertinent findings were reported: increased occipitobregmatic skull diameter, saddle nose, blue sclera, short neck, and short bowed extremities. The fontanelles were large and brain convolutions were flattened. The cartilaginous bone presented irregular islands of calcification, more marked in the skull; the long bones crushed between the fingers like corrugated paper and cut surfaces bled readily. The long bones presented irregular areas of excess callus from healing fractures and platybasia of the skull was present.

Boyd and Fox (32) give a follow-up study and report of seven cases of congenital pseudarthrosis after massive bone grafting, four of them originally reported in 1941. This article is less optimistic than the first report as to the results obtained, and the authors conclude that adequate protection is necessary until the bone has developed a new medullary canal and the tibia compares in size and strength to the normal, this period usually extending past puberty. The occurrence of refracture, recurrent sclerosis about the fracture site, or narrowing of a previously reformed medullary canal is felt to be an indication for reinforcement grafting. Bony union occurred after bone grafting but refracture was prone to occur, and union is again as difficult to secure as originally. There was the same pattern of bone re-absorption from unknown cause following the refracture. Neurofibromata were not found at surgery.

The seven cases are presented in some detail followed over a period of three to twenty-two years, and each case is discussed. One case came to amputation. The authors believe that grafting should be carried out early, at three to five years. Donor bone from a parent was often used and complete and prolonged immobilization was necessary, four to six months in a cast, followed by brace protection usually until after puberty.

Hauser (33) states that cast treatment of the congenital clubfoot is extremely difficult before the age of three months and that development of the foot and leg is jeopardized by this form of treatment. He advocates early institution of treatment and describes in detail the technique for utilizing cohesive bandage (which adheres to itself but not to the skin). Each component of the deformity is corrected with adhesive strips overlying a basic encircling bandage of leg and foot, and the completed corrective dressing is again completely covered with another layer of this cohesive bandage. Additional bandage is added daily obtaining additional correction during the first week, the entire dressing changed then, at two or three week intervals. Over-correction is maintained until walking begins. In six of his cases subcutaneous achilles tenotomy was necessary and three had plantar fasciotomies. Outer shoe wedges with bracing in abduction and external rotation are started when weight bearing begins. Seventy cases thus treated led to excellent correction, however there were three who required more correction at four to six years, and five in which the deformities were considered "congenital anomalies."

According to Goldstein (34) many combinations of congenital fusions of the carpus and tarsus are possible, the most common being congenital fusions of the lunate and triquetrum. Sixteen cases were found reported in literature. The fusions are characterized by true bony continuity without evidence of a pathological process which might have caused fusion, and the presence of a line representing the intended joint. One case is reported in a 42 year old Jewish female as an incidental x-ray finding. There have been four cases of congenital fusion of the capitate and lesser multangular reported and the author adds another case, a 55 year old Jewess with this anomaly in both wrists.

The many possible combinations of congenital fusion of the tarsal bones are discussed and the literature summarized.

One additional case of symmetrical humeral-ulnar synostosis in a 3-7/12 year old Jewish boy is reported. There is an associated fusion of all the visible carpal bones, synostoses of toe and finger phalanges, and bilateral clubfoot with fusion of the talus, calcaneus, and cuboid.

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SECTION 2

DISEASES OF GROWING AND ADULT BONE

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Growth of Bone

Elgenmark (1) has compiled tables to show the normal ossific center development. These tables which indicate all the ossification centers (68 in number) on one side of the body, show that the appearance of other centers cannot be predicted from the date of appearance of a single center.

In the article under review he compares his previously determined normals with the number of epiphyseal centers at a given height and age in several developmental diseases. The series is short and he feels final conclusions cannot be drawn.

In evaluating a case, distinction must be made between males and females, for girls show a greater number of centers, particularly at the height of 70 cm. and at the age of 10 months. The number of centers is also more closely correlated with height than with age. The tables can be utilized to determine whether or not body development is normal. In breast-fed infants usually there are no changes before four months. No case of mongolism had delayed skeletal development, cases of cryptorchism showed marked retardation and a hermaphrodite showed development more closely resembling a female.

The author concluded that by utilizing his tables one could gain some knowledge of disturbances in skeletal growth as well as the degree of development.

Haas (2) in a series of very significant experiments on dogs, observed the effects of various combinations of metal staples across epiphyseal plates. His results indicate that wires or staples placed unilaterally across the epiphyseal cartilaginous plate will arrest longitudinal growth on the side of insertion and also on the opposite side of the same plate to a lesser degree. Consequently loss in length of the bone may occur. In addition, he showed that growth is active after temporary retardation, but is less than on the normal side. Some of the plates showed premature closure after temporary retardation.

Ross, (3) in a study of longitudinal growth in conditions involving prolonged disability of the lower extremity, found that growth arrest may result at the knee. He presents thirteen patients, of which nine were from a group of 92 cases of tuberculosis of the hip (10%).

It is his impression that the atrophy of disuse leads to partial degeneration of the cartilage which is in turn followed by complete degeneration with subsequent bony bridging. The latter he feels is due to some secondary factor, such as the abnormal stresses of a faulty gait.

Fuller and Woolf, (4) of the Physical Development Centre report "a high incidence of leg shortening with resultant scoliosis among recruits sent to the centre for a remedial course for various postural or other defects". They give no statistics because the group is not a cross section of the British Army. The recruits were mostly $17\frac{1}{2}$ - $18\frac{1}{2}$ years of age. The shortening varied from $1/4$ to $1-1/4$ inches. Remarkably few gave history of symptoms, injury, or poliomyelitis. Shortening of $1/4$ - $1/2$ inch was compensated for by raising the heel. No lifts over $1/2$ inch were given. In discrepancies over $1-2$ inch, the affected side lowered a corresponding amount.

Rickets:

Sydow (5) reports the results of his observations and studies of the serum calcium, inorganic phosphorus and alkaline phosphatase in premature and full term infants when fed on formulas of breast milk and cows milk, with and without the addition of Vitamin D. He found that at birth the serum phosphatase in the premature, was about $1-\frac{1}{2}$ times as high as the full term infants, and the serum calcium about 1 mg% lower. The serum phosphorus was the same. In the premature infants fed on breast milk the phosphatase remained high even with the addition of Vitamin D, and somewhat lower when they were given only cows milk. The addition of Vitamin D to the cows milk brought the values to normal. Premature infants fed on breast milk showed a considerable lower serum phosphorus level than the normal. The addition of Vitamin D caused no change while the addition of cows milk produced some improvement. Vitamin D added to a cows milk formula brought the levels near normal. In studying the serum calcium levels he found that it was low in premature infants fed a formula of human milk or cows milk but the addition of Vitamin D improved the serum calcium level. Roentgen findings of rickets were observed as early as the 14th day, and neither the addition of cows milk or Vitamin D could with certainty prevent the development, although roentgen changes were noted more infrequently in the subject fed cows milk. Histologic changes typical of rickets were found in several of the cases.

Man, (6) reports the results of experiments to find the factor causing retarded growth in chickens, when fed on a diet containing 2% dried yeast. They looked for a specific phytase inhibiting substance, but could not confirm its presence in yeast. They attribute the retardation of growth by yeast to the inorganic phosphate.

Portal, (7) discusses the use of various exercises to correct bony deformities by strengthening the weak muscles that caused or contributed to the deformity. The author makes suggestions for recreational activities that may be of value in promoting the specific remedial exercises.

Infantile Cortical Hyperostosis

Shuman, (8) reports a case of infantile cortical hyperostosis in a 4-month old child. This illness is characterized by fever; irritability; anemia; brawny, facial edema; x-ray evidence of hyperostosis of the manible, ribs, and clavicle; and unaltered growth and development of the patient. The etiology is undetermined, and the course is unaffected by penicillin, sulfadiazine, antihistaminics and elimination diet.

Zeben, (9) presents three cases of infantile cortical hyperostoses, a disease first reported by Caffey in 1939. The only symptom was swelling of the lower legs. X-ray showed extreme thickening of the periosteum of the shafts of the bones of the leg, as well as along parts of the skeleton not associated with swelling. These three cases occurred within the same family and all showed forward curvature of the tibia.

Cartilage

Gordon, Perlman and Schechter (10) report a case of diffuse inflammation of cartilaginous tissues of the body. They were unable to find its counterpart in American or foreign literature. The condition occurred in a 34 year negress and manifested itself with cough, dyspnea, swelling and tenderness of knee, ankle and ears. The patient gave a negative venereal history. Biopsy of articular and nonarticular cartilage was reported by various authorities as "diffuse degenerative change in cartilage", "unable to offer any interpretation" and "rheumatoid arthritis".

Swenson, (11) has reviewed the literature of osteochondritis dissecans and osteochondromatosis. He concludes that trauma plays a definite role in producing non-infectious sequestration of subchondral bone from an articular surface with deficient nerve and vascular supply in the former. It is apparently a predisposing factor also in initiating the metaplastic process of synovial chondrification in osteochondromatosis. He points out that the bones and joints begin their differentiation from a single type of mesenchyme and its derivatives may retain the power of cartilage formation throughout life. Thus, with repeated traumatic irritation, hyperplasia of the synovial membrane may occur and metaplasia supervene as an individual reaction to form beads of cartilage in the relatively undifferentiated connective tissue of the villous synovial membrane. The author adds ten cases that were treated by surgery with satisfactory results. He feels this is the treatment of choice.

Osteopetrosis

Fairbank, (12) reviews the clinical features of Albers-Schonberg's disease (Marble Bones), pointing out that the syndrome is characterized by abnormal density of bones, with or without fragility, a strong tendency to anemia which may be severe or fatal, and optic atrophy. There may be intermissions, remissions, or complete cessation of the developmental error before growth ceases. The petrosed bone is white-gray on section. X-ray usually makes the diagnosis, but heavy metal poisoning should not be confused.

A report of a single case of marble bones or Albers-Schonberg's disease is made by Rugg-Gunn, (13). The patient was a 23 year old female who was admitted because of complaints of sinus trouble. X-rays revealed some sort of generalized bone disease, (no description is given). The family history was irrelevant except for vague rheumatoid symptoms in the mother. The patient showed only slight bossing of the frontal bones. The serology was negative. The serum calcium was 15 mg. per 100 cc. and the serum phosphorus was 4.9*per cent. In the discussion, Albers-Schonberg's original case is described. No members of the patient's family were available for study. She was essentially symptom-free.

* mg. per cent

Osteopoikilosis

In the fourth section of the Atlas of General Affections of the Skeleton, Fairbank, (14) presents the subject of osteopoikilosis or Osteopathia Condensans Disseminata. The condition is rare and is manifested by multiple dense spots in many bones. It tends to be familial and affects males twice as often as females. A congenital etiology is accredited by some, but some cases show spots in bones that are not ossified until after birth. There are no significant blood changes. The x-rays show dense spots, varying from 2-10 mm., which parallel the long axis of the bone and are most common in the epiphyses. In most cases, they appear in all bones except the skull, ribs and vertebra. The course tends to be uneventful with little or no change in the x-ray over the years. Occasional cases are associated with dermatofibrosis lenticularis disseminata.

Melorheostosis

Fairbank, (15) reviews the 47 cases that have been reported of this rare condition, and includes several case reports with reproduction of radiographs. The distinguishing features of this disease, which differs from generalized osteopetrosis or "marble bones" are: (1) changes confined to the bones of one limb; (2) the distorted outline of an affected bone; (3) pain, occasionally severe, sometimes unbearable; and (4) limitations of movement in the joints formed by the affected bones. None of these features are invariably present. It is observed in both sexes but is more frequent in the male. The age incidence is 5 to 54 years, with 75% under 36. It probably begins in childhood or in fetal life. Pain is the most frequent symptom. Shortening and deformity of bone occur. Scleroderma appears as a complication. Radiographs show the dense, structureless appearance of "marble bones" in parts or the whole of the bone; the "flow" of dense streaks and blotches may be interrupted or continuous and suggests the flow of candle-grease down the limb. The bone changes are progressive. Available histological reports show sclerosing areas, with compact overcrowding of lamellae arranged in a bizarre manner, with an interlacing pattern of immature and adult bone.

Metaphyseal Dysostosis

Fairbank, (16) describes the clinical features as well as radiographic features and pathology of the only case of metaphyseal dysostosis reported in the literature. This condition is differentiated radiographically from dyschondroplasia by the absence of the columnar arrangement of the cartilaginous metaphysis and of mottling of the epiphysis, either partly or wholly. The spots of calcification and ossification in the metaphysis vary in size, shape, and density, and they differ from the circular dense spots which are seen in the "healing stage" of dyschondroplasia.

Osteoporosis

Albright, (17) presents a classic discussion of osteoporosis, which should be read by all, whether in the field of surgery or medicine. He has come to the following conclusions: "(1) Osteoporosis is defined as the category of decreased bone mass where the disturbance is a failure of the osteoblasts to lay down bone matrix. (2) Three factors which influence osteoplastic activity are: (a) steroidal hormones, (b) mechanical stresses

and strains, and (c) nitrogenous building blocks. (3) In respect to bone matrix, the steroids can be divided into anabolic steroids (estrogens and androgens), and anti-anabolic steroids (adrenal cortical "S" hormones), and anabolically-inert steroids (progesterone). (4) The age of entrance of adrenal cortical "N" hormone on the scene is termed "adrenarche"; the age of exit, the "adrenopause". The adrenarche is usually synchronous with the menarche; the adrenopause is normally considerable later than the menopause. The adrenal cortical "S" hormone is produced at the same level during childhood, age of sexual maturity, and senility. (5) The osteoporosis of old age is partly to be attributed to the loss of gonadal hormones and the adrenal-cortical "N" hormone and responds to estrogen and testosterone therapy. (6) The osteoporosis of the post-menopausal state is to be attributed to the decrease in estrogen production following the menopause and responds to estrogen and testosterone therapy. (7) The osteoporosis in Cushing's syndrome and in the adaptation syndrome of Selye is to be attributed to an excess of the anti-anabolic adrenal cortical "S" hormone and responds to testosterone therapy. (8) The adrenocorticotrophic hormone, by releasing "S" hormone from the adrenal cortices, likewise produces osteoporosis; the effects of A.C.T.H. on panhypopituitarism is demonstrated. (9) Evidence is presented to suggest that the effect of testosterone in stimulating anabolism may be partly, but probably not wholly, due to its property of causing decreased production of the adrenal cortical anti-anabolic "S" hormone rather than entirely to a direct anabolic property of its own. (10) The production of bone matrix is undoubtedly influenced by the availability of certain nitrogenous substances; evidence is presented which suggests that the height of the serum albumin is an important factor."

Kesson, Morris, and McCutcheon, (18) have made an excellent attempt to determine the etiology of generalized osteoporosis in the aged, in which they reviewed a series of 80 patients over 40 years of age drawn from the poor sections of the population of Glasgow. These findings were compared with radiographs taken of the spine during the years of 1939-1941 of 227 patients over 40 years of age from the same strata of the community. They have stated that when the cause of osteoporosis is known, and when the cause can be removed, the condition can be cured. As an example, the administration of Vitamin D with a generous supply of calcium to the patient with osteomalacia leads to rapid recalcification of the bone. The cause of the senile osteoporosis has not yet been determined accurately, but by their investigation they feel that endocrine disturbance, arteriosclerosis, and anemia can be excluded; but the lack of exercise may play a minor part in the etiology. Also, that reduced intake of minerals over a long period of time was probably an important factor, although it was not possible to prove by radiographic evidence of calcium deposition in the rarefied skeleton with a rich supply or rich diet in calcium and phosphorus. They thought that a very lengthy period was required to restore it. Although no improvement was effected radiographically in the patients treated with a high intake of minerals for a period of fifteen months, no increase of osteoporosis was noted. Thus, they felt that it was possible to prevent further decalcification and the occurrence of complications by administration of a high diet rich in calcium and phosphorus. Vitamin "D" was not shown to be concerned in the etiology, but they advised the administration in moderate doses.

Lauber, Weber and Greenfield (19) report a case of idiopathic extreme osteoporosis involving the spinal column and thoracic cage with collapse of the front of the chest. In association with this, there was considerable anemia and, as with similar cases recorded in the literature of this subject, no cause was discovered and all treatment was unavailing. This case again reveals that the treatment of this condition will be rational only after the chemistry of bone metabolism is better understood.

Albright's Disease

In 1937, Albright, Butler, Hampton and Smith described a syndrome now known as Albright's disease. This is characterized by the presence of multiple bone lesions, areas of skin pigmentation, and precocious puberty in females. They suggested the term "osteitis fibrosa disseminata" to distinguish the skeletal changes in this syndrome from those associated with hyperparathyroidism. The name "Polyostotic fibrous dysplasia" was introduced one year later by Lichenstein and later modified to fibrous dysplasia. McMahon (20) reviews a case in which there are three separate and distinct bone changes: (1) Fibrous dysplasia, involving every bone in the body, (2) a disturbance in the epiphyseal growth involving both bone and cartilage, and (3) wide spread bony atrophy. Of the three changes, fibrous dysplasia was by far the most striking.

Aegerter, (21) finds that neurofibromatosis is a condition characterized by multiple nodules of fibroblastic hyperplasia of nerve supportive tissue. It is associated with scoliosis, asymmetric hypertrophy and focal lesions usually misdiagnosed as bone cysts. It or its associated conditions accompany congenital pseudarthrosis and fibrous dysplasia in many cases. It is well shown that congenital pseudarthrosis is not a result of neurofibroma. It is suggested that neurofibromatosis and fibrous dysplasia are caused by defective mesenchymal germ plasm.

Gaucher's Disease

Windholz and Foster (22) point out that in Gaucher's disease there are frequent signs of bone formation in the medullary cavity and report two cases. The new bone formation is not excessive and occurs not only in bone structures adjoining absorptive changes, but also in parts of the medullary cavity where no bone destruction is evident. In the two cases reported, bone cylinders occupied the peripheral portions of the proximal two-thirds of the medullary cavity. The bone tissue is laid down in the intercellular fibrous structures of Gaucher proliferation as a product of direct metaplasia of collagenous fibers, hence is present only in advanced stages of the disease process. Roentgen signs of pathological ossification occurring in areas situated about absorptive lesions involving simultaneously more remote areas of the medullary cavity, in which no destructive changes are evident, may be of diagnostic significance in Gaucher's disease.

Hand-Schuller-Christian Syndrome

An article by Smyth, (23) presents observations of the syndrome of membranous bone involvement, diabetes insipidus, and exophthalmos, called Hand-Schüller-Christian disease. Hand ascribed the etiology to tuberculosis, but later suggested a neoplastic, benign, myxomatous condition. The presence of diabetes insipidus pointed to the pituitary and emphasized the endocrine factor. Warthin's biopsy studies called attention to the accumulation of foam cells in the affected area and called attention to the cholesterol

deposition, suggesting an abnormality of fat metabolism. Further studies indicate that neither the originally described triad nor the foam cell found on section is an entirely reliable diagnostic aid. Wallgren, Faber and Mallory suggest that Letterer-Siwe's disease occurring in two-year olds, Schüller-Christian disease occurring in older children, and eosinophilic granuloma of adults are manifestations of the same general process. The latter have suggested an infectious, possibly virus, etiology. Best results in treatment have been a combination of excision and x-ray.

Leontiasis Ossium

Way, (24) reports the case of leontiasis ossium in a spinster who died in 1944 at the age of 73. At 20, a bicuspid tooth was filled, following which she developed a hard swelling in the gum above the tooth and similar changes in the cheek. Dental treatment followed, but the swelling spread to the other cheek and to the frontal region. In 1939 she had a transient hemiplegia associated with a blood pressure of 222-/95. Four months before her death she lost muscular control and became intensely deaf. The article includes a picture and radiographs of the lion-like head. The condition caused little inconvenience to the patient's health. The base of the skull was involved in this case but the mandible was not. The patient had colds and the author states that this and the dryness of her nose suggests that the mucosa lining the sinuses is the major source of nasal secretion.

Osgood-Schlatter's Disease

In an attempt to determine the true nature of Osgood-Schlatter's disease, Hughes, (25) reviews the normal anatomical and radiological features of the tibial tuberosity in varying stages of its development. His investigation through careful roentgenological study in twenty cases shows clearly that the clinical features are almost certainly due to pathological changes primarily within the ligamentum patellae rather than in the apophysis and the ossification at the site of insertion is accounted for by the partial tearing of the ligamentum from the bone. The insertion of this tendon at the smooth portion of the tuberosity is not as firm as it is in the groove, and if the ossification is higher than the ligamentum, it may be due to an extension of an osteoplastic reaction or to a metaplasia of the fibroblasts. In any case it seems the etiology or the initiating stimulus was injury to the ligamentum directly or indirectly. Trauma was believed by both Osgood and Schlatter to be the cause of a painful tuberosity; this author feels the same. The pathology which the trauma produces is not clearly understood. It is believed to cause separation of the tongue-like epiphysis from the diaphysis by some. Others believe the injury interferes with the blood supply and so causes an aseptic necrosis of the apophysis and still others believe there is a disorganization of the apophyseal centers or actual avulsion of a fragment of bone. The first radiological sign of this disease is thickening of the ligamentum patellae. Studies by Hughes indicate the condition is the same type of pathology as myositis ossificans. Hughes states also that the appearance of the fragmentation is a normal stage in the apophyseal development. His conclusion in the study of 20 cases of Osgood-Schlatter's disease is that the disease is primarily an intra-ligamentous rather than epiphyseal condition and the disease is a tendonitis rather than an epiphysitis.

Kridelbaugh and Wyman (26) report 13 cases of Osgood-Schlatter's disease seen in a period of nine weeks at a large Naval Recruit Training Center. In this study they suggest a classification of three types: (1) Tibial tubercle epiphyseolysis; (2) Tibial tubercle fragmentation (a) with and (b) without, epiphyseolysis; and (3) Tibial tubercle necrosis (a) with and (b) without epiphyseolysis. They treated all their cases conservatively with thigh cross-strapping to relieve the pull of the quadriceps tendon upon the tubercle. The etiology was ascribed to trauma, aggravated by exercise carried on during training.

Osteogenesis Imperfecta

Fairbank and Baker (27) discuss hyperplastic callus formation, with or without evidence of a fracture in osteogenesis imperfecta. In 1943 Brailsford suggested that the subperiosteal hemorrhage which at times occurs in osteogenesis imperfecta, might be due to scurvy. The authors studied eight cases, six of whom were osteogenesis imperfecta and two were not definite but were suggestive. In these there was formation of intensely calcified local callus or excessive formation of ossified callus around the shaft;*formation of bony excrescences on the shafts of long bones, especially on the interosseous borders; and all with little or no evidence of fractures. This excessive callus is often very irregular and not the usual fusiform type as often seen in fractures. When there was a fracture present with this excessive callus formation, this formation extended far beyond the fracture. This enlarged portion often was open meshed or coarsely cancellous bone. Some of the fractures in these cases heal normally with the usual amount of callus formation. This excessive formation of periosteal bone occurred most in the femur and humerus. Bony excrescences were found most often in the radius and ulna and usually at the interosseous side. They might be rounded or spicular in shape. These findings were first found in children from the age of 1 to 15 years. There were curvatures of the long bones in all these cases and malformations of the other bones. They had osteoporosis and the spine often showed bi-concave vertebrae. These complications occurred at times while the patient was in the hospital and with adequate diet and vitamin C. The swelling in some of the cases was so rapid and great that it was suggestive of a sarcoma and a biopsy was done. The microscopic examination showed chondroid or semicartilaginous tissue which is a transition between fibrous, mucoid and cartilaginous tissue. A section through the tissue from the outside in, shows the dissolution of the muscles and connective tissue to that of calcified cancellous tissue on the inside. The authors feel that there is a definite relationship between this excessive callus formation and osteogenesis imperfecta. It is more common in the femur than in other bones. They do not agree with Brailsford as they do not think that any of these cases showed any evidence of scurvy. The subperiosteal hemorrhage in scurvy shows a smooth enlargement and the above are often very irregular. In scurvy the shadows disappear but these do not. These cases have only in one case shown evidence of hemorrhage in the skin or gums. In traumatic myositis ossificans there is not this extensive callus formation. In these cases trauma was the only possible cause that they could detect.

Fairbank (28) gives a very excellent discussion of osteogenesis imperfecta and presents several cases. The condition is characterized by fragility of the skeletal bones. The cause is unknown. He groups the cases into * ,often with permanent enlargement of the shaft;

pre-natal and post-natal, but there is no clear cut division, the fractures occurring earlier in the former. The prenatal is more severe and these often die early. Osteogenesis tarda is the term applied to the late cases. Heredity and familial influences are apparent in a minority of the cases. It may be inherited through either parent. Both sexes are involved, the female a little more frequently. Blue sclera is common especially in the post-natal group. Otosclerosis may occur in those who live to the third decade but has been reported as early as the 13th year. Bickel found deafness in 45% of the hereditary and 17% of the non-hereditary cases. In adults with blue sclerotics 60% develop otosclerosis with or without bone fragility. Laxity of joints is not uncommon in the family. Osteomalacia with bending of the bones may be present and is striking in the pelvis. The number of the fractures varies markedly, some as high as 100. Refracture may occur several times but may be due to osteoporosis of disuse. Most severe cases are dwarfed and this is accentuated by the curvature of the legs and spine. Scoliosis may be severe. The skull is broad, with prominent parietal and occipital bones. The ears are often directed down and out. The teeth may be poorly calcified and waxy. The intelligence is average. The musculature is extremely weak but much of it may be due to the fractures and deformities. There is a tendency for improvement. The main pathology is the imperfect formation and imperfect calcification of the bone trabeculae. Islands of cartilage are seen, especially under the periosteum. The periosteum is thickened and there is a failure of formation of the normal shell of cortical bone. The medullary contents may be fibrous, lymphoid and fatty. There is often a decrease in the osteoblasts. In the radiographic appearance there are three groups. Type I, the thick bone type, seen most in severe pre-natal cases, have short major long bones, which are usually broad and thick, the proximal ends being most affected. Other bones are osteoporotic. Type II is the slender, fragile type which occurs in the pre-natal cases that survive and in all the post-natal cases. All the bones are osteoporotic and the long bones are usually slender. The cortex is thin. They may be of greater density at the old fracture sites. Transverse lines of dense bone, straight or wavy, often mark the ends of the metaphyses. The fibula may be just a faint line. The skull is thin. The vertebral bodies are shallow, spread, biconcave and rarefied. In Type III we have osteogenesis imperfecta cystica but it is rare and in it the cystic changes are more pronounced in the lower extremities. It is progressive.

Conklin and Koloski (29) report a case with typical findings of osteogenesis imperfecta except that the patient was not deaf. Osteogenesis imperfecta is a disease characterized by multiple fractures, generalized osteoporosis, blue sclera, deafness and relaxed ligaments. According to Sante it exists in three forms, (1) congenita, (2) tarda or infantile and (3) idiopathic osteopsathyrosis. The first two are congenital and have blue sclera but the last does not have the blue sclera. In congenita, the fractures occur at birth and these patients usually die in infancy. In the tarda form, the fractures begin about the time they begin walking and the idiopathic have the fractures start about the age of three years. Blue sclera is a typical Mendelian characteristic, and 50% of children of a heterozygotic person and a normal person will have the blue sclera and brittle bones. These individuals are usually short and thin. The head often shows prominence of temporal, occipital and frontal areas.

Vandemark and Page (30) report massive hyperplasia of bone following fracture in two cases of osteogenesis imperfecta. The condition must be differentiated from malignancy, myositis ossificans, ossifying hematoma, and osteomyelitis. The reaction is apparently due to a quantitatively

exaggerated repair on the part of the osteoblast.

Sickle Cell Anemia

A case of sickle cell anemia is described by Weil and Lerner (31). It shows unusual roentgen changes in skull, tubular and flat bones. The bones of the skull vault were extremely thick; the tables could not be delineated because of the increased density of the calvarium. The mastoid showed an almost complete lack of pneumatization. There was an irregular defect in the left parietal bone measuring 1.5 x 2 cm., with a sclerotic margin. The metacarpals and phalanges showed almost complete loss of the trabecular pattern of the shafts and marble thickening of the cortex. The second phalanx of the right middle finger and the fifth right metacarpal bone showed cyst-like areas within the medullary cavity with expansion of the shafts. Both fibulae and ulnae showed cortical thickening. Some bones showed widening and increased trabeculation of the medullary cavity with thinning of the adjacent cortex. There was marked variation in density suggesting cyst formation. The upper third of the left tibia showed marked overgrowth of cortical bone with encroachment on the medullary cavity.

Paget's Disease

Hamilton (32) presents the findings in the maxilla of a well established case of generalized Paget's Disease. The enlarged maxilla stretched the overlying mucosa so that the vessels were distinctly outlined. Dental roentgenographic examination showed moderate to advanced resorption of the alveolar process around the remaining teeth. The maxillary bone revealed zones of almost confluent trabecular pattern, in a background of almost uniform diffuse increase in density. In the upper right molar region, there was an area which revealed several nodular appearing sclerotic portions. A fragment of bone removed from the maxilla for biopsy showed the usual histological findings in this disease.

Meirowsky (33) calls attention to the significance of vacuoles in physiological and pathological conditions, and offers additional evidence for the resemblance of vacuoles in Paget's disease to various other disorders. Using a technique employing Mallory's connective tissue stain, the author demonstrated virus-like bodies in the vacuoles of common plantar and genital warts, and in four early cases of Paget's Disease found similar virus-like bodies in the vacuoles. He could not demonstrate the same bodies in the advanced cases of Paget's Disease.

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SECTION 3

TUBERCULOSIS OF BONES AND JOINTS

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One of the most complete and carefully compiled works on bone and joint tuberculosis presented during the year 1948 was the volume entitled "Skeletal Tuberculosis" written by Sanchis-Olmos (1) who is Assistant Director of the National Institute of Reeducation of Invalids in Madrid, Spain. This volume has been translated by Kuhns of Boston. The volume represents a most excellent review of the entire subject and contains a full and complete bibliography of the literature thereto pertaining.

A good brief but thorough thumb-nail sketch and survey of Tuberculosis of Bones and Joints was written by Malkin (2) of London. It covers the methods of spread and the pathological sites of these conditions as well as the diagnosis and treatment.

The nursing care of the patient with bone and joint tuberculosis with its problems and solutions has been presented well in two articles in the American Journal of Nursing. (3) (4)

Although the use of B.C.G. Vaccine has not received much popularity in the United States it behooves us to review the history and development of its use. McKone (5) of Canada has written a most carefully prepared and thorough article entitled "Review of the Literature on B.C.G. Vaccine and a Discussion of its Present Day Value in Protection against Tuberculosis." Its conclusions are that B.C.G. must be made in centers specializing in its production in order to avoid contamination and danger. If this is done the vaccine is innocuous for both animals and humans. Local and general reaction following vaccination is negligible. The figures of its value in study with controls cannot be denied. It has a definite place for employees of sanatoria and hospitals and for children who are tuberculin negative and who have parents in hospitals for tuberculosis. Wallgren (6) of London has offered some principles for the use of B.C.G. Vaccine which are worthy of review. They are: 1-The vaccinated person must be repeatedly tuberculin tested and protected against exposure to infection by tuberculosis until they become tuberculin positive. 2-Nothing is gained in B.C.G. Vaccination to tuberculin positive people. 3-In a known case of exposure it is advised to wait at least six weeks and then vaccinate only if the patient is tuberculin negative. There is no danger in vaccination in a positive person but this confuses the picture. 4-The duration of B.C.G. sensitivity is usually from two to ten years. The longer it lasts, means that a subclinical infection with tuberculosis has been acquired. 5-Tuberculosis in B.C.G. cases means that conferred immunity is only relative. 6-There is no reliable way to distinguish tuberculin sensitivity due to B.C.G. and that due to infection. 7-Immunity holds as long as a positive tuberculin test is positive and if a positive test goes to a

negative then revaccination with B.C.G. is demanded.

Studies in the chemotherapy of tuberculosis using mainly laboratory methods were done with the sulphones, promizole and sulphretone. (7) (8) (9) Although high therapeutic activity was shown in vitro with these chemicals there was little or no clinical evidence of in vivo activity in the human. These chemicals as well as an antibiotic called subtilin (10) from the B. Subtilis were not used in any case of bone or joint tuberculosis.

The use of streptomycin both in laboratory and experimental animals as well as in the human found a prominent place in the literature for 1948. Corper and Cohn (11) using laboratory animals found that streptomycin does not destroy the virulent human tubercle bacilli nor completely retard their development in vivo. It does not affect the viability of avirulent human tubercle bacilli in vivo. In experimental virulent infection streptomycin did retard tuberculosis activity but it could not prevent a lethal outcome and in their series no animal escaped. The mechanism of streptomycin action in vivo is not known. It has too an unstable in vitro retarding unit value in simple mediums for the tubercle bacilli. They suggest much more controlled studies of this antibiotic and stress the use of streptomycin as an adjunct and advise the continuation of standard sanatorium treatment. Pfuetze and Pyle (12) described the uses and limitation of streptomycin in tuberculosis. They state that it is effective in at least fifty per cent of patients treated. Used early in the disease streptomycin may result in disappearance of symptoms and the X-ray may show evidence of healing. In the chronic case the surgical treatment is more successful after adequate chemotherapy especially where draining sinuses are present. The limitations listed are: There is little effect on far advanced pathological changes; it suppresses tuberculous infection but does not eradicate it; there is a development of resistant strains and finally there is the element of toxicity in its use. They recommended a dose of one gram a day for five to six weeks. Amberson and Stearns (13) stated some general conclusions in relation to the use of this drug in pulmonary disease chiefly. It promotes control of acute inflammatory changes by arrest of bacterial activity. It may help in avoiding extensive caseous necrosis by putting less demands on the patient's vital resistance thus giving respite for the natural healing process. Relapse and drug resistance are discussed and the time of administration is advised to be long in the desperate case and short in the mild one. Above all a plea is made not to abandon rest with the use of this new agent. Feldman (14) states that streptomycin causes a loss of progressive momentum in tuberculosis and also causes earlier tissue healing. Its limitations are that it has less action in vivo than in vitro and that its use does develop drug resistance. The tissues must be rehabilitated by natural resistance after the acute infection is suppressed. Therefore chemotherapy plus medical and surgical help is always needed and streptomycin is viewed as a valuable adjunct.

Specific work was done and reported on drug-resistant tubercle bacilli in patients under treatment with streptomycin. Wolinsky, Reginster and Steenken (15) presented a series of forty-seven studied patients who were under an average dose of one gram a day. In general cultures of tubercle bacilli isolated from untreated cases were sensitive to 1.0 mcm cc of streptomycin but tubercle bacilli resistant to the action of 10 mcm of streptomycin/cc were found commonly in patients under streptomycin treatment. The longer the duration of treatment with streptomycin the more drug resis-

tant cultures were obtained - for example, thirty-seven per cent of their patients developed drug resistance after twelve weeks. Their plan was then to give the drug for four to six weeks at which time about seventy-five per cent of positive cultures may be expected to be still sensitive. They stressed that streptomycin resistance is a relatively long lasting characteristic of the tubercle bacilli both in vitro and in vivo. The results of treatment with streptomycin in patients harboring drug resistant organisms have not been encouraging. Bernstein, D'Esopo and Steenken (16) reported a series of forty five patients with pulmonary tuberculosis treated with one gram of streptomycin for one hundred and twenty days. Prior to therapy the tubercle bacilli isolated from the patients were sensitive to 1.0 mcm of streptomycin per ml of medium. After one hundred and twenty days of streptomycin administration, tubercle bacilli were recovered from the sputum or gastric washings of thirty-one patients or sixty-nine per cent of their series. In twenty-six of these patients the tubercle bacilli were resistant to 10 mcm of streptomycin per ml, that is, eighty-four per cent of the patients in this group, showed drug resistance. Even eighteen strains were found to be capable of growth in over 1,000 mcm. It appeared that streptomycin resistant tubercle bacilli had the greatest rate of development in the second month of therapy. They concluded that the amount of the dose was not as important as the time factor and that there must be clinical and laboratory correlation in the use of this antibiotic.

Other articles have appeared in the literature during this year concerning the use of streptomycin. These represent in main a review of the clinical use of this antibiotic and are referred to in the bibliography (17-23) for general reference use.

Several articles were published describing the use of streptomycin in the treatment of bone and joint tuberculosis with and without sinus formation. Michele and Krueger (24) reported twelve cases in which surgery and streptomycin were both used. A hip and shoulder case were presented in detail in which streptomycin both pre and post-operative combined with joint toilet and fusion was used with excellent results. Nalls and Moyer (25) report two groups of patients with draining tuberculous sinuses treated under a different dosage plan. In the first group of patients twenty-three in number, twenty-one were cured under a dosage of 1.8 grams per day in five divided doses. The duration of therapy was between three and eight months. In the second group of nineteen patients under a dose of 1.0 grams a day in two divided doses, eleven were cured and the rest rapidly clearing in therapeutic duration of only one to three months. In the second group there was less toxicity noted and less resistant strains developed. They felt that the two dose daily method maintained a better blood level. Their general plan in the treatment of draining tuberculous sinuses was to give streptomycin for thirty days after healing or a total of one hundred and twenty days whichever is shorter. Brock (26) reported a series of twelve patients with a grand total of sixty draining sinuses, in ten of these patients the sinuses lead directly to bone. 1.8 grams of streptomycin was given daily for ninety days to six, and to the remaining six for one hundred and fifty days. There was mild toxicity in many of these cases but none of a permanent nature. All the patients had a sense of well being and there was an average gain of fifteen pounds. Fever was abated in all cases. Of the sixty sinuses, fifty-nine were closed eight months after starting the streptomycin therapy. Sinuses closed in from one to twenty weeks. It is stressed that the effect of streptomycin is enhanced by adoption of the surgical prin-

ciple of free drainage and sequestra removal. Bickel and Young (27) present sixteen patients treated with streptomycin, three with multiple joints involved and four sinuses present before treatment. One hundred and twelve days was the average duration of treatment and one hundred and thirty-four grams was the average total dose. There was toxic reaction classified as mild to moderate in nine patients. Of the sixteen treated there was a favorable result in nine, fair in one, no benefit in four and in two it was too soon in the therapy to make a decision. The sites involved in this series were: knee, spine, ankle, wrist, shoulder, elbow, ilium and sacro-iliac joint. The authors suggest a dose of one gram daily for ninety days. Kincade and Saxton (28) reporting the use of streptomycin in the treatment of one hundred cases of all types of tuberculosis included three cases of tuberculous osteomyelitis. These cases received one gram daily for eight weeks in two daily doses. In two the sinuses cleared up with one recurrence and in one there was temporary improvement. No bone changes were noted by x-rays.

(Note: Today the trend continues toward a smaller dose of streptomycin and an increase in the time interval of administration coupled with such drugs as para-amino-salicylic acid. Our present regimen at the Fitzsimons Army Hospital is two grams of streptomycin with twelve grams of para-amino-salicylic acid every three days for thirty doses. Results are good with practically no limitation.)

The old fixed concept that every case of a tuberculous lesion of the spine presented a narrowed disc space with vertebral body destruction cannot be held today in its entirety for many proven cases of tuberculous spondylitis do not give this picture. A most instructive pathological and x-ray review of multiple tuberculous lesions of the spine is given by Feuchtwanger (29). His conclusions are given here as they represent a progressive viewpoint in orthopaedic pathology and diagnosis. He presents a case of multiple areas of spondylitis showing combined pathological changes. This case was followed for eighteen months with x-ray and finally came to post-mortem examination. Tuberculosis of the spine is not always a purely destructive process and many times shows bone production or sclerosis and this finding therefore does not mean evidence of a secondary infection. The disc space in tuberculosis may show two changes: It is often preserved despite extensive bone destruction of several bodies; early narrowing may be caused by extrusion of the nucleus pulposus into the softened bony or ligamentous structures. The disc space in pyogenic infection shows early and complete loss due to proteolytic enzyme action from the polymorphonutrophiles in the exudate. Pyogenic spinal infection is usually confined to the neural arches and tuberculosis is uncommon here. In the spread of tuberculosis of the spine the extension of the abscess is under the anterior longitudinal ligament and there is surface invasion of the vertebral bodies anteriorly. The annulus fibrosis shows little reabsorption even in contact with the abscess. In pyogenic spread however, there is direct extension through the disc from body to body and this is not found in tuberculosis. Gibbus is uncommon in non-tuberculous spondylitis. Spinal cord pressure and slow spastic paralysis is common in tuberculosis. Meningitis on the other hand is more common in the early stages of pyogenic osteomyelitis. It is to be remembered however, that the secondary infection of a tuberculous psoas abscess may give the pathological and x-ray changes of osteomyelitis only. The bone in tuberculosis of the spine assumes two pathological forms: it may be destructive,

that is exudative or caseous; or productive, that is sclerotic. Both of these forms may be seen in multiple involvement of the spine. Pott's disease is the first type with extension into the disc space with body weight compression causing gibbus. In the second form the body and disc space are maintained. In the healing of both types the bone marrow is stimulated to fibrosis and osteogenesis by toxic substances liberated by the necrosis of the tubercle bacilli. There is gradual apposition of layers of sclerosis in the diseased bone layers. Sclerosis is an aseptic necrosis due to loss of blood supply as shown by Bosworth and Cleveland. Both caseation and sclerosis may be seen at the same time. By x-ray the old concept was bone destruction without sclerosis and minimal new bone formation. Today many cases are noted with sclerosis which do not have secondary bone infaction. In pyogenic osteomyelitis the rarefaction is more definite and circumscribed. A paravertebral abscess may be the first sign of disease with no alteration of the vertebral body or disc space in the productive type. This has been definitely demonstrated by Bosworth.

A most complete and thorough article on Tuberculosis of the Spine in Children was written in 1948 by Cave (30) at Massachusetts General Hospital.

Norcross (31) reports two most interesting cases of compression of the spinal cord due to direct extension from a tuberculous pulmonary abscess. Only two cases have been previously reported so it is assumed that this condition is rare. The first case had a tuberculous cavity at the base of the right upper lobe and from this focus a tract extended along the third and fourth ribs, destroying portions of these and the third and fourth pedicles of the thoracic vertebrae. It then entered the intervertebral foramen and thence to the spinal canal and enveloped the cord and compressed it. In the second case a sinus extended from an apical pulmonary lesion around to the back involving the spinous processes of the third, fourth, and fifth thoracic vertebrae and thence into the intervertebral foramen, into the canal and caused cord compression. These cases reported are therefore not true Pott's disease and not the common extension from an abscess about a spondylitis extending through the disc space and posterior ligament to the cord.

Dalgarno, Puckey and Nelson (32) report a case of empyema followed by Pott's disease in which the eleventh thoracic vertebra was compressed but in which there was no paralysis.

Dott (33) presents the treatment of Pott's paraplegia by skeletal traction and anterior decompression in a series of twenty-one patients. Eighteen anterior decompressions were done and of these twelve were in the dorsal area. The average duration of symptoms was two years. All cases showed a spinal fluid block, in fifteen it was complete and in four partial. Paravertebral abscess was present in all but one case. The cord compressing agents were described as follows: displaced disc in eight; bone of internal gibbus in four; sequestration in three; debris in two; and fluid abscess in one. Traction is advised with surgery. The operation is one of a posterolateral approach, the erector spinae are displaced inward. Removal of ends of ribs, transverse processes, pedicles and some portions of the bodies follows. The anterior surface of the theca is then exposed. A burr is found useful in sclerotic bone cases. The indications for operation are as follows: rapidly progressive paraparesis; progressive paraparesis in spite of treatment by fixation and postural correction; in the chronic case in spite of treatment a slight or moderate paraparesis develops or exists; and cases where spasm prevents fixation. There were three deaths in eighteen

cases, two from uremia and one from cord injury. Results obtained were; twelve of fifteen had complete recovery; two nearly complete recovery and one was too early to state. All cases recovered from the spinal block and all showed a good recovery of general health. At the present time all cases are placed in traction and are grafted following exploration. In three cases sinuses developed and in two of these the sinuses are healing well.

Somerville and Wishart (34) report a most unusual case of Pott's disease of the spine with rupture of the aorta. An abscess from the 8th dorsal extended into the esophagus and thence into the mediastinum and an eroded rib protruded into the aorta producing hemorrhage and death. They mention one other case of suspected tuberculous spondylitis of the 12th dorsal and final aneurysm of the aorta with rupture in the thoracic portion.

A case of tuberculosis of the greater trochanter is reported by Martin (35) in which the x-ray showed no sclerosis of bone and the operation revealed bone caseation and a millet seed bursa. The author doubts that sclerosis means secondary infection.

A most unusual functional result in a proven case of tuberculosis of the hip treated by conservative methods is reported by Upshaw and Bickel (36). The patient was a four year old colored male who was followed for three and one-half years. Cystic necrosis was present at the epiphysis of the neck of the femur. Exploration revealed normal cartilage but biopsy tissue was positive for tuberculosis. The patient was casted for fourteen months and then wore a caliper brace for ten months more. Final examination revealed a healed process and only the slightest limitation of flexion and extension, all other motions of the hip joint being normal. (Note: A proven case of tuberculosis of the knee joint (exploratory biopsy) treated with streptomycin and immobilization for eight weeks at the Fitzsimons Army Hospital presented a healed lesion and complete normal function and appearance at the end of two years.)

Nissen (37) gives an excellent review of the surgery for arthrodesis of the tuberculous hip in England and the present trends toward certain techniques. He states that no matter how efficient external fixation is, a closed tuberculous infection of the hip very rarely leads to spontaneous fusion and that some form of bone graft is necessary. Five types are reviewed: 1-Hibbs--using a detached trochanter for a bridge across the joint line is not used because in adolescence there is too much cartilage at the trochanteric site. 2-Ilio-femoral--the time of operation is about the tenth year and follows weight-bearing ambulatory treatment. Operation is done through a windowed spica using a Smith-Petersen approach. A free full thickness iliac graft is wedged into slots in the greater trochanter and ilium just above the joint line. Correction of joint contracture is done two months later by subtrochanteric osteotomy well away from the joint. Good fusion is reported in seventy per cent of the cases. Failure in ilio-femoral arthrodesis alone is cut down remarkably by use of a high osteotomy in combination. 3-Brittain--massive tibial graft driven between fragments of osteotomized femur just below the lower margin of the joint into the ischium and beneath it, the upper end of the femoral shaft is displaced inward. Many satisfactory results are reported but there is always danger of sciatic nerve damage. 4-Trumble--a low horizontal graft placed posterior to the sciatic nerve between the tuberosity of the ischium and the femur gives good results

and avoids sciatic nerve injury. (Note: Van Gorder of Boston has presented a modification of this method with excellent final results.) 5-Wilkinson-uses a high displacement osteotomy getting the upper end of the lower femoral fragment into contact with the pelvis. The lesser trochanter unites with the ischium without use of graft. Many early successful fusions are reported and this procedure may be used at an early age before a graft is feasible and even in the presence of sinuses. Deformity and strain are removed by inward displacement of the whole femoral shaft.

Dobson (38) of England actually presents an analysis of fifty cases of arthrodesis in tuberculosis of the hip joint in which the extra-articular ilio-femoral (with attached iliac end) arthrodesis was used. Forty of these fifty patients have been followed for a period of two years or more. The indications for arthrodesis are stated: Unsound fibrous ankylosis at the end of the initial period of conservative treatment; painful fibrous ankylosis without deformity, and finally the late development of flexion-adduction deformity. The operation is performed when the disease is quiescent usually at the twelfth or thirteenth year. Fifty-eight per cent were done between the eleventh and twentieth years and twenty-six per cent between the twenty-first and thirtieth years. The mortality was two per cent. There was solid bony ankylosis in eighty-seven and one-half per cent. Full working capacity was present in eighty-seven and one-half per cent and two and one-half per cent did part time work. These cases were immobilized for six to nine months and were allowed weight-bearing in three months.

Birdsong and L'Engle (39) describe the fifteenth reported case of multiple cystic tuberculosis of the bones. The patient was a thirteen month old white male with cystic tuberculous lesions in the flat and long bones as well as in the bones of the hands and feet. The osseous lesions were secondary to tuberculosis elsewhere and were spread through the blood stream.

Jorio (40) reports 34 cases in which bone fistulae or cold abscesses have favorably responded to local treatment with antiseptic solutions. He describes 3 compounds containing ether, alcohol, phenol, iodine, bichloride of mercury and zinc chloride.

Martin (41) introduces his article with the statement that the existence of tuberculous rheumatism is doubted by many individuals in the United States. Most American authors believe that this condition is merely an occurrence of rheumatoid arthritis in an individual who happens to have an associated visceral tuberculosis. The author quotes French and Swiss authors who believe that in such cases chronic polyarthritis associated with erythema nodosum has developed in tuberculous children. The author feels that if a streptococcus may be accused of being an etiological factor, so may other bacteria such as the gonococcus, brucella, and the salmonella group.

The author describes 4 cases in which findings of tuberculosis are well documented by post-mortem examination. There was associated polyarthritis in all patients. The literature favoring the theory that tuberculosis may be a contributing factor in the development of the rheumatoid type of polyarthritis is reviewed.

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SECTION 4

INFECTIONS OF BONES AND JOINTS

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In reviewing the literature for 1948, with respect to bone and joint infections, one cannot help being impressed by the continuing superior results attained in the treatment of acute osteomyelitis through antibiotic therapy as compared with those before the advent of such therapy. Most investigators recommend surgical drainage during the optimum period as an adjunct to antibiotic therapy. There is general agreement on the fact that such therapy should be started as early as possible and should be given for a relatively long period in all cases. During this year, there have been no new developments in the treatment of secondary or chronic osteomyelitis, reliance still being placed on the eradication of dead and infected bone, building up the patient's resistance, and the use of antibiotics locally and by general administration. The difference in organism sensitivity to the antibiotics probably best explains the inconsistent results obtained in various series and individual cases. Through the use of antibiotics, surgery tends to assume a minor role in the treatment of acute bone infection but becomes bolder and more radical in dealing with the chronic infections.

Allen (1) reports the results in 16 cases of acute osteitis treated in the pre-penicillin era which are contrasted with 17 cases treated by penicillin. The main differences were that in the latter group the acute toxemic stage was of shorter duration, there was less bone destruction and aspiration was not so often necessary.

Trueta (2) finds that there is not complete agreement on the results of treatment in osteomyelitis after four years experience with penicillin. Although the initial septicemic phase can be pretty well controlled with chemotherapy, the effect on the bony focus is not always satisfactory. In all but the earliest cases, surgical treatment consisting of linear incision of the periosteum, drilling of the bone in the involved area, primary suture and immobilization, is advocated. Relatively large doses of penicillin for three weeks are advised.

Dennison (3) describes the results in 56 cases of osteitis which were treated with penicillin. Thirty of these cases were acute with marked toxemia; in nine cases, the bone lesion was the outstanding feature and toxemia was slight; and in seventeen cases, chronic pyogenic bone infection was present. In sixty-nine cases treated before the advent of sulfa drugs, the mortality was 33 1/3%, while in seventy cases treated mainly with sulfathiazole, the mortality was 10%. In his present series, the mortality was zero. Sequestrum formation requiring surgical interference occurred in six cases. The average hospitalization period was thirty-two days. The author states that no time limit can be set for the administration of penicillin and that routine marrow puncture appears to be the only certain method of

control. He states that the administration of penicillin should continue until the marrow puncture is sterile. Methods for handling subacute and chronic infections of the bone are described.

Leveuf (4) does not agree with the usual treatment now being used in acute osteomyelitis. He normally drains soft tissue abscesses between 15 and 20 days and condemns bone operations in the acute stage. Formerly, the wound was left open but has been closed since the advent of penicillin. This author doubts the value of penicillin treatment until after surgical interference. Six hundred cases of acute osteomyelitis have been treated and the author believes that the first site of lodgement of staphylococci in hematogenous osteomyelitis was not usually the metaphysis but in the midshaft near the entrance of the nutrient artery.

Tucker and Hollenberg (5) compare the various methods of treatment and contrast the results obtained in osteomyelitis. Thirty-nine cases comprise the series. The most satisfactory results and the lowest period of hospitalization were obtained in those cases wherein 50,000 units of penicillin daily was administered for a period of at least twenty-eight days. They believe that early metaphyseal decompression in conjunction with a long course of penicillin therapy gives better results than with penicillin alone. During surgery, stripping of the periosteum is particularly advised against. They believe that the sedimentation rate is a good barometer as to the progress of the case in that it remains elevated as the case progresses unfavorably and decreases as the case improves. The need for early diagnosis and immediate therapy is stressed.

Self (6) compares the results of treatment before and after the advent of sulfanilamides and penicillin. He reviews and appraises cases of acute hematogenous osteomyelitis admitted to Babies Hospital, New York City, from 1930 through 1946. During this period there were 138 cases. The author describes the dramatic onset and severe symptoms and points out that bony changes cannot be demonstrated by x-ray before the seventh to twelfth day. Trauma and infection elsewhere in the body were the chief etiological factors. Hemolytic staphylococcus was the offending organism in 87 cases. Hemolytic streptococcus was the causative organism in 27 cases. The causative organism was undetermined in the remaining cases. The femur, tibia and humerus were most commonly affected but involvement of nearly all bones of the skeleton was present and 24 cases had more than one bone involved. Seventy per cent of patients with streptococcus infection were under three years of age. In the staphylococcus infections 60% were over three years of age. There were eleven deaths in the series but only one of the cases received chemotherapy.

Wilkinson (7) points out that with early diagnosis and adequate treatment with penicillin and sulphadiazine, the mortality is almost zero and bony changes are minimal. He discusses the differential diagnosis and prognosis. Before the sulphonamides and penicillin the mortality in 674 cases was 20.7%. Between January and December, 1947, there were seven deaths in 177 cases, a mortality of 3.9%. A detailed description of the therapy is given.

Vuori and Sulamaa (8) have collected 83 cases of acute and chronic osteomyelitis that were treated by penicillin. Surgical treatment was required in some cases. The initiation and rate of penicillin administration varied so much that reliable statistics were difficult to obtain; however, the authors conclude that early penicillin administration and adequate dosage are very important factors. They believe that surgical interference is necessary in a certain per cent of cases.

Trueta and Agerholm (9) discuss effectively and in detail, the care and treatment of acute hematogenous osteomyelitis. They stress the need for early diagnosis. Treatment is described under four headings: Penicillin, Surgery, Immobilization and After Care. These authors believe that surgical drainage is indicated when pus is present. During the recovery period, x-ray and sedimentation rate determinations are considered the most helpful indicators of stages in the disease process. (Note: Excellent illustrations accompany this article and it is well worth reading in toto. This paper has been republished in another bulletin (10) as shown in the bibliography.)

Metcalfe (11) describes the therapy in several cases of osteomyelitis. One case maintained a bacteremia for seven days in spite of heavy dosage with antibiotics. The importance of massive, specific antibiotic dosage and adequate supportive treatment is emphasized. Attention is called to the use of streptomycin in appropriate cases.

Buchman (12) reports a case of chronic osteomyelitis of many years duration in a 28 year old female illustrating the misuse of antibiotics. She was treated with several courses of penicillin and improper surgery which resulted in the development of severe urticaria and finally necessitated the application of a tent for administration of oxygen. The penicillin produced no improvement in the bone infection or the draining sinus. The author outlines the proper treatment of cases after recovering from the reaction to penicillin. Wound cultures were made. Sensitivity of the organisms to both penicillin and streptomycin was determined. Streptomycin was used intramuscularly and locally in conjunction with proper surgery which consisted of saucerization after excision of skin scar and finally plastic closure. Fortunately, the organisms were sensitive to streptomycin but were not toxic to the patient. The result was excellent.

Beerman (13) reports the treatment of seven consecutive cases of acute hematogenous osteomyelitis of the long bones in infants and children. The two infants treated in this series manifested rapid resolution of the disease under penicillin therapy, which consisted of 20,000 units every three hours for nineteen days in one case, and 15,000 units every three hours for ten days in the other. The good results, the author feels, are principally due to the fact that penicillin therapy alone, or in combination with sulfadiazine, was started early in the course of the disease in all patients. A high degree of suspicion for this disease is considered important. Conditions that must be differentiated from acute osteomyelitis are acute arthritis, cellulitis, scurvy, syphilis, thrombo-phlebitis, poliomyelitis and rheumatic fever. If these cannot be differentiated conclusively, it is preferable that they be treated unnecessarily with penicillin rather than that possible osteomyelitis go untreated. Surgery was used in one of these cases. The author believes that the amount of bone destruction and the necessity for

surgery are related directly to the number of days delay in instituting penicillin therapy. A plan has been developed by the author for the medical handling of this disease and is discussed in some detail.

O'Brien and Mira (14) describe the results obtained through the use of penicillin and/or sulfonamides in 24 cases of acute hematogenous osteomyelitis in children. No surgical treatment was employed but multiple aspirations of soft tissue abscesses were carried out in some cases. They give a detailed account of the treatment employed, complications which ensued and results obtained.

Hutter (15) believes that osteomyelitis in infants should not be considered a benign infection and that all minor infections in the newborn should be considered as precursors of severe infections and treated accordingly. In the cases reported, some antecedent infection was present in the majority. It requires about one week for typical bone changes to occur that can be visualized in the x-ray; however, there is one significant finding early in the course of the infection that may lead us to suspect osteomyelitis; namely, widening of the joint space. The author describes the results in six cases of osteomyelitis in infants under six months of age from 1943 to 1947 that were treated with penicillin and sulfadiazine. The mortality was zero as contrasted to a group of twelve cases between 1934 and 1943 wherein the mortality rate was 58%. All of these cases were due to staphylococcus infection. Ninety per cent of the cases reported showed involvement of the hip joint. The joint capsule becomes distended by inflammatory exudates and lateral dislocation of the femoral head from the acetabulum is common. This dislocation is the earliest roentgenographic finding and should cause one to suspect an inflammatory process in and about the joint. One should give a guarded prognosis for complete recovery without deformity, especially in the severe type of infection.

In statistics by the Navy (16) diseases of the motor system rank high as a cause of morbidity and disability and osteomyelitis as one of these diseases, has consistently shown the highest number of sick days per case. During the war years (World War II), the average annual incidence rate for osteomyelitis was 35.9 per 100,000 strength, compared to 30.6 for the period 1936 through 1939. Comparing the relative number of cases of osteomyelitis which were deemed to have existed prior to entry into the Service, it was found that for the period 1936 through 1939, an average of only 4.8% of the cases existed prior to entry into the Service, compared to an average of 17.6% for the war years.

McKelvey (17) discusses the management of both acute hematogenous osteomyelitis and chronic osteomyelitis, stressing the surgical treatment of the latter.

Illingworth (18) in a textbook of Surgical Treatment, describes the clinical course and treatment of acute and chronic osteomyelitis in detail. There also is a brief description of developmental diseases of bone and bone tumors. Another paper by the same author (19) discusses diseases of joints in a concise manner.

Spinelli (20) presents a case of septicemia in a seven day old infant in which multiple abscesses, acute osteomyelitis of the head of the humerus, and pyarthrosis of the same shoulder joint developed. This case was successfully treated by aspiration of the joint, penicillin locally and systemically, along with immobilization of the joint and supportive therapy.

Toumey and Shipp (21) call attention to the importance of the use of penicillin, obliteration of osteomyelitis cavities through the use of small bone grafts and muscle transplants, primary closure after removal of the infected bone and soft tissue where possible and the use of split grafts to temporarily or permanently cover exposed bone. Thirty patients were treated in this series. The duration of symptoms varied from six weeks to 36 years, with an average of $9\frac{1}{2}$ years. The technique of management and postoperative care in these cases is described in some detail.

Graham, Coventry and Ghormley (22) describe the results in 68 cases of chronic osteomyelitis treated at the Mayo Clinic during 1944 to 1946. All patients underwent surgical treatment with penicillin being given parenterally. In 27 cases, the wounds were packed open and in 41 cases they were closed primarily. The rate of healing was 67% in the first group and 88% in the second. These authors believe that in selected cases, primary closure is safe and curative, and considerably shortens the period of morbidity and disability. They contend that radical excision of infected bone, combined with penicillin therapy, results in a better chance for complete eradication of the disease.

Hays (23) admirably describes all aspects of sclerosing, non-suppurative osteomyelitis (Garré's), and presents a case from the onset of symptoms until complete healing has taken place. Attention is called to the similarity between the early stages of this type of osteomyelitis and Ewing's endothelioma.

Reynolds and Zaepfel (24) believe that the management of osteomyelitis secondary to infected, compound fractures, should consist of debridement and saucerization with closure of the wound if this can be done without excessive tension; otherwise, by belated closure, using split thickness grafts. They recommend that three months elapse before doing any bone grafting. The authors discuss the results in 42 cases. Cancellous iliac bone is advocated for use in grafts in these cases. Methods for doing such grafts are described.

Delgarno, Puckey and Nelson (25) describe a case of acute osteomyelitis of the femur in a two year old child. There were no manifestations of such involvement by x-ray for 24 days following the onset of illness. In spite of treatment with penicillin and sulfadiazine from the day of admission to the hospital, the infection continued to spread and finally involved the entire shaft of the femur. Constitutional symptoms were never pronounced. One large sequestrum and several smaller ones were removed surgically and the child was discharged from the hospital, walking, after thirteen months.

MacDonald (26) describes compensatory hypertrophy of the fibula in a 52 year old man in whom most of the tibial shaft had been removed thirty years previously because of osteomyelitis.

Scott and Preston (27) describe a case of Brodie's abscess of the tibia in a miner, age 62, consisting of two noncommunicating abscesses in the distal part of the bone. Soft tissue abscesses were aspirated separately and 50,000 units of sodium penicillin injected into each cavity. This process was repeated three times during the next four days. The patient also received sulfadiazine and sodium penicillin intramuscularly during this period. Nine days following the initiation of the above treatment, the cavity was excavated surgically and filled with cancellous bone chips. A needle was sutured into the depth of the bony cavity and penicillin instilled every three hours through it until removal on the seventh postoperative day. The patient also received penicillin intramuscularly. The wound healed primarily. There was almost complete obliteration of the cavity by x-ray three and one-half months following the operation.

Simmons and Wyman (28) describe a puzzling diagnostic problem in a seven year old girl. Trauma to the left ankle occurred four months prior to admission and surgery was performed seven days following admission. Clinically, the tentative diagnoses were early giant cell tumor, sarcoma and Brodie's abscess. *Staphylococcus albus* was found on culture.

Rosenberg and Vest (29) describe the clinical features of osteitis pubis in four cases, two of which followed a retropubic-prostatectomy and two following transurethral resection. They state that it is probably a more common clinical entity than is generally recognized and that the x-ray findings are characteristic but may not be seen early in the disease. The etiology is considered to be infection plus urine retention in the retropubic space. It is considered a self-limited disease, the treatment being symptomatic and supportive.

Guri (30) states that certain cases of pyogenic osteomyelitis of the lumbar spine may show the same symptomatology as acute, suppurative arthritis of the hip. During the early stages, there is not a single radiologic sign which is pathognomonic of pyogenic spondylitis. The article gives excellent differential diagnosis of this condition. Treatment is subdivided into that for osteomyelitis involving the vertebral body alone, that involving the neural arches only and that involving both. The author believes that drainage of deeply situated abscesses is unnecessary as they will be reabsorbed later. He concludes by saying that the end result of pyogenic infection of the vertebral body is the formation of a vertebral synostosis.

Brunner (31) has classified twenty-two cases of osteomyelitis of the skull and face according to cause and clinical course of the disease, and believes that the cause does exert an influence on the course of the disease. Osteomyelitis caused by acute frontal sinusitis or by surgery upon the sinuses is considered to have an unfavorable prognosis. The author believes that antibiotics are of no value in primary chronic osteomyelitis.

Armer (32) describes a case of acute osteomyelitis of the coronoid process following extraction of a third molar tooth. The infection was controlled by incision, drainage and irrigations, but the coronoid process became honeycombed and was removed as a sequestrum. Subsequent regenera-

tion took place within the periosteal sheath and no atrophy of the temporal muscle occurred.

Birch (33) describes a case of acute paratyphoid B infection with accompanying pain in the lower back that turned out to be a paratyphoid osteomyelitis of the spine. A tentative diagnosis had been made of early ankylosing spondylitis and the patient was placed on a plaster bed for three months. X-ray examination of the spine showed complete destruction of the body of the fifth lumbar vertebra. Further immobilization resulted in a stable and symptomless spine. The author warns that although the patient appeared symptom free three years after onset of the above infection, further symptoms and even abscess formation may develop at any time.

Rozansky, Ehrenfeld and Matoth (34) report two cases of paratyphoid osteomyelitis, one occurring in a one year old infant and the other in an adult, thirty-two years after initial infection. Attention is called to the fact that the lumbar spine is involved in about 70% of the cases showing lesions of the spine. The authors believe that trauma, strain, fatigue, and pyrexia may upset the equilibrium between the latent bacilli and the defense mechanism of the body in those cases wherein bone lesions appear many years after the initial infection.

Dehlinger (35) describes a case of abdominal aortic aneurysm with an adjacent *Salmonella* osteomyelitis of the spine, with autopsy findings. The aortic aneurysm was considered to be arteriosclerotic in origin and it was believed that the osteomyelitis of the spine developed secondarily as a result of latent infection. A total of 34 grams of streptomycin given over a period of fourteen days, had no effect on the *Salmonella* infection. The author calls attention to the fact that *Salmonella* osteomyelitis of the spine is a very uncommon condition.

Royster, Kirby and Wilbur (36) describe a case of typhoid osteomyelitis of the ribs in a 73 year old man who had had a general typhoid infection two years previously. A tender swelling appeared over the lower anterior chest several months after he had recovered from the initial infection. On aspiration, *E. typhi* were seen on culture. X-rays showed no evidence of bone or lung involvement. Sections of the involved ribs and a part of the sternum were removed on two different occasions but the wound did not heal. On this admission there was a draining sinus in the anterior chest wall which showed no communication with the lung under lipiodol injection. The Widal test was positive for typhoid in dilution of 1:640. A total of 36 grams of streptomycin was given five days prior to operation and continuing for thirteen days postoperatively. At operation, the draining sinus and associated scars were completely excised along with adjacent ribs and a portion of the sternum. En bloc dissection was carried out so that normal tissue surface remained everywhere except over a thickened pleura. Wound was packed with iodoform gauze and skin edges approximated except where the ends of gauze protruded. The wound was completely healed 55 days after surgery. The authors conclude that the use of streptomycin in such a case will not replace adequate excision. They call attention to the fact that in the typhoid era, surgeons

found that only radical surgery was effective in controlling bony lesions.

Lowbeer (37) describes the pathological findings in three spines wherein patients died of subacute brucellosis, melitensis type, and who had developed clinical symptoms of spondylitis. Gross specimens showed small and large areas of destruction of the discs and contiguous vertebral bodies in the lumbodorsal spine. Occasional small osteomyelitis foci were found in the anterior or central portions of the vertebrae. Exostoses were frequent. The microscopic findings are described in detail. The author states that, although one could not tell with absolute certainty, the above lesions were actually caused by *Brucella*. No cultures were taken directly from the affected vertebrae but the inference was strong because the lesions occurred in cases of active subacute brucellosis with positive blood cultures.

Gariepy (38) reports an interesting case of destructive osteomyelitis of the fourth lumbar vertebral body in a man 56 years of age, which developed fifteen days following urinary infection due to transurethral resection of the prostate. Pain was the dominant symptom. There was no response to penicillin, sulfadiazine or plaster immobilization. Surgical drainage of the paravertebral abscess gave temporary relief but the infection spread upward to the bodies of the first and second lumbar vertebrae. *P. aeruginosa*, which was highly sensitive to streptomycin, was cultured from the aspirated pus. The patient was given 3,000,000 units of streptomycin daily for ten days. His recovery was uneventful. The diseased area as seen by roentgen examination, was fused by intervertebral bridging of bone with sclerosis of the discs.

Lamphier (39) presents a case of localized coccidioidal infection of the os calcis in a 39 year old soldier that did not respond to general and local treatment. A below-knee amputation of the extremity was performed and was followed by satisfactory wound healing without further dissemination. The author believes that the removal of well advanced bone or joint infection peripherally should always be considered in such infection because of the great possibility that multiple foci will develop.

Davis (40) describes a case of coccidiomycosis in which the diagnosis was established postmortem.

Armer (41) describes a case of acute osteomyelitis of the mandible following extraction of a third molar tooth but apparently not caused by the extractions. Subsequent history revealed placement of an amalgam filling two days previous to the extractions in the tooth around which the infectious bone process had started.

Berman and Sugar (42) have described a case of osteitis pubis following prostatectomy. Etiological factors are discussed. X-ray changes in the symphysis do not appear until the third or fourth week. Ankylosis of the symphysis generally occurs in the healing process.

Wilson (43) presents 25 cases of chronic osteomyelitis in which the discharging sinuses had been present for an average of nineteen months.

Other previous types of treatment had been unsuccessful. The following principles formed the basis of the author's treatment: (a) Investigation of wound bacteria; (b) Radical sequestrectomy after adequate preoperative preparation; (c) Use of streptomycin and penicillin before, during and after surgery; (d) Meticulous wound care after surgery to prevent contamination.

Sensitivity tests were made on gram positive organisms and the schedule of antibiotic treatment is described in detail. Sequestrectomy is considered the most important single part of treatment. The average time for wound healing was about eighty days. The author states that the use of streptomycin offers no panacea for treatment of chronic osteomyelitis but when combined with thorough sequestrectomy, is beneficial in promotion of the healing process. (Note: This is a well written article that should be read in toto.)

Varadarajan (44) describes bone lesions in twelve patients out of 1,000 cases of syphilis as treated in a Burmese hospital. The tibia was the most frequently involved bone (four cases), showing an osteoperiostitis of the shaft in three cases and an acute osteitis in the fourth. A constant finding in all cases was an increased sedimentation rate and this is considered as the most important guide by the author in assessing activity of the local process.

Esguerra-Gomez and Acosta (45) confirm an older observation that bone lesions of leprous origin are located exclusively in the hands and feet. A total of 483 lepers were examined in this study. It was found that in neural leprosy as well as in the lepromatous and mixed cases, there is frequently a more differentiated trabecular structure in the epiphyses of the phalanges, metacarpals and metatarsals than in healthy individuals. The cortex of the diaphysis is thinner and the medullary canal is wider than normal. Vacuolization follows the above changes. Along with adjacent areas of rarefaction and hypercalcification, there is occasionally a noticeable widening of the proximal ends of one or more phalanges which covers the adjoining phalanx like a cap (hooded). This is considered typical of the disease. Leprous reabsorption takes two forms: simple reabsorption and reabsorption following atrophy. Mutilations are generally symmetrical. In the hands, the reabsorption stops at the carpus, while in the foot it usually stops at Lisfranc's articulation. Leprous Whitlow is a true osteomyelitis and presents the same appearance as ordinary osteomyelitis radiographically. Fractures are frequent in leprosy and heal by callus formation, as demonstrated by three of these patients. Perforating plantar ulcers may cause infectious arthritis. Hypertrophic arthritis is also common due to reabsorption and atrophy. In 46 healthy children of lepers and twelve without disease, there appeared to be no difference in the time of appearance of epiphyseal ossification centers.

Breck, Basom, Hart and Herz (46) report three cases of inflammatory bone lesions of unusual symptoms and x-ray appearance. They point out that chemotherapy has altered the symptoms and radiological study. The reported cases had many of the characteristics of malignant bone tumors. Osteogenic sarcoma and Ewing's tumor were considered in two of the cases. The authors emphasize the importance of a careful biopsy before instituting radical treatment.

Bellis (47) calls attention to the importance of tissue tension in edema of the extremities, stating that it may rise to ten to twenty times that of normal. Immobilization and elevation reduce the tissue tension of an inflamed extremity and are of distinct value in supporting the natural defense mechanism of the body in extremity infections. The use of such treatment appears to rest on a rational physiologic basis. It appears that the application of heat under these circumstances is harmful. Immobilization by plaster cast is considered more efficient than that obtained by any other method.

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SECTION 5

ARTHRITIS AND ALLIED CONDITIONS

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A review of the literature on arthritis reveals no lack of interest or poverty of writings on this subject. Arthritis is increasingly being recognized as a major economic and social problem whose etiology, pathogenesis and treatment remain unsolved. These factors undoubtedly contribute to the failure to obtain a simple universally acceptable classification. There is much discussion of chrysotherapy, physical therapy and indications for surgical procedures in the management of arthritis.

HISTORICAL AND GENERAL CONSIDERATIONS

Arthritis is the oldest disease found to occur in man as well as in other forms of vertebrate life according to Bach (1). In his interesting historical and chronological account of arthritis he relates that as climatic conditions changed to become cold and wet, during the Reptile, Mosasaur and Dinosaur ages to the time of man, arthritis became more distinctly evident. Fossilized skeletons of monsters who lived 110,000,000 years ago have shown evidence of arthritis. The ancient Egyptians in their hieroglyphic writings tell of man suffering from arthritis, and as early as 1550 B. C. deformities were described and treatment prescribed by them. Removal of foci of infection was recommended by the Egyptians as early as 668-628 B. C. Hippocrates, 460-370 B. C., is credited with writing the first definite clinical picture of arthritis and an attempt at classification. In 1591 Ballonius first applied the term rheumatism specifically to articular disturbances and made a clinical differentiation between acute inflammatory rheumatism and gout. This differentiation was elaborated upon by Sydenham. During the 15th Century Villobolos referred to joint complications in syphilis. In 1593 Petrus Forest of Alkamaar wrote of a case of swollen knee associated with gonorrhea. In 1687 Wallaston reported the discovery of uric acid in gouty tophi. William Cullen, 1777, divided rheumatism into acute and chronic. Richard Pott, 1779, described tuberculosis of the spine. David Pitcairn, 1788, recognized the cardiac complications of rheumatic fever. Edward Sandifort, of Layden, 1793, illustrated gross changes in osteoarthritis of the hip. In 1800 Landre Beauvais first described the clinical picture of rheumatoid arthritis under the title of asthenic gout. Heberden in 1802 described nodes found on the terminal joints, which have since taken his name. In 1810 William C. Wells clearly described "Rheumatism of the Heart." In 1848

Sir Alfred Garrod discovered the high uric acid content of blood in gout. In 1884 Petrone grew gonococci from exudates of gonorrheal joints, and in 1888 Weichselbaum recovered pneumococci from joints. In 1897 Goldthwait, Painter and Osgood differentiated between atrophic and hypertrophic arthritis by the use of x-ray findings. In 1907 Sir Alfred Garrod's son, Sir Archibald, made a clear distinction between rheumatoid arthritis and osteoarthritis. In 1907 Nichols and Richardson described the pathology in chronic deforming arthritis. In the same year Pemberton pointed out that obesity is a factor in many cases of osteoarthritis. In 1910 Billings crusaded for the removal of foci of infection. Miller and Lust, in 1915, advocated the use of non-specific vaccines in the treatment of arthritis. In 1916 Chase and Fine wrote on the use of cinchophen and aspirin. In 1928 Forestier investigated the use of gold therapy in chronic rheumatoid arthritis.

A classical review of the American and English literature of recent years, the ninth such review prepared by the Editorial Committee of the American Rheumatism Association, has been edited by Hench, et al (2) (3). Since the eighth review was prepared concerning this literature for the year 1940, a great amount of work has progressed on the subject of arthritis, even in spite of the war years. This new literature has been classified, collated and presented in a clear, logical arrangement. The economic and social importance of rheumatism in the United States, the British Isles and Sweden and the classification of arthritis with a plea for the adoption of one classification for use throughout the United States were discussed; also, in order, the gamut of arthritic conditions were individually treated, covering the incidence, clinical data, roentgenographic and laboratory findings, etiology, pathogenesis, prognosis and treatment.

Another review of the arthritides was prepared by Horwitz (4), which covers the important progress made in their diagnosis during the past few years.

In dealing with rheumatism, Douthwaite (5) considers there are three major problems: the first problem is to define, or rather to delimit the term; the second problem is to explain the origin of those diseases which we call rheumatic, and, the third problem is that of the treatment of rheumatism. He states that since the first two problems are unsolved, it is not surprising that the third is in an unsatisfactory state. Commenting on the third problem, he refers to the uselessness of many forms of therapy and cites chrysotherapy as being the only major advance made in the treatment of arthritis for a century. The realization that every arthritic joint is an orthopaedic problem from the beginning and the appreciation of the value and limitations of spa treatment and physiotherapy are also encouraging advances of the last thirty years.

The fact that rheumatic diseases is our biggest medico-economic problem is emphasized by Kelly (6), who points out that of the chronic diseases it ranks first in the number of cases, second in the production of costly deformities and fourteenth as a cause of death. He estimates that one out of every twenty individuals in this country is afflicted by arthritis, which makes it imperative that all physicians have an adequate knowledge of these conditions so as to make an accurate diagnosis and employ rational treatment.

Indications of the high incidence of arthritis in the United States is reflected in the markedly increased rate, which occurred in the Navy during

the war years. In a statistical analysis prepared by the Navy (7) (8), the highest incidence occurred in the age group 45 to 49 years. The average annual incidence rate during the period per 100,000 for males was about two and one-half times greater than females. All races showed an increase, which more or less paralleled, although the rate was higher in the white race. (Ed. Note-This statistical study would be more enlightening if it included a statistical account of the diagnoses of the disease entities included in the report.)

Ishmael (9) reviewed the arthritides particularly as they occur in the aged. The degenerative types occur most frequently. Rheumatoid arthritis, gout, rheumatic fever, osteochondritis dissecans, the shoulder-hand syndrome, malum coxae senilis and bone atrophy with its multiple causes are discussed.

The incidence of arthritis is shown to increase with age and be higher in an industrial population than a non-industrial group by Ferguson (10), who quotes from Scotch statistical records. He urges for an expansion of treatment facilities in industrial centers where they can be available to the majority.

The establishment of an arthritic clinic consisting basically of four specialists, a physician, a surgeon, a medical officer in charge of physical medicine and a clinical biochemist, is described by Nicol, Waugh, et al (11). As needs arise, a radiologist, an ear, nose and throat surgeon, a dental surgeon, a psychiatrist and a venereologist are added. There is team work consultation on each patient, who passes to the care of a particular specialist according to the indications for treatment, after which the patient is returned to the clinic for review.

In order to provide trained personnel to care for arthritic patients, the establishment of a Department of Rheumatology in teaching hospitals where rheumatologists can be trained has been advocated by Savage (12), Buckley, Mason and Nicholson (13), Ellman and Dunn (14), and Heald (15).

Many classifications, some based on clinical manifestations, others on pathologic, roentgenographic or etiologic characteristics have been proposed in the past, but none have been universally accepted. Bach (16) relates that since the ideal treatment of arthritis is based on its cause, a classification based on etiology is particularly desirable. He presents a classification of the arthritides, which is a modification of that adopted by the Subcommittee on Arthritis of the New York City Welfare Council's Committee on Chronic Illnesses and that of the Committee on Classification of the American Rheumatism Association. A classification based on whether the pathology is (1) chiefly articular, or, (2) chiefly non-articular is suggested by Heald (17), who accordingly describes a number of guides for diagnosis and some essential keystones of treatment.

VARIOUS TYPES OF ARTHRITIS

In a discussion of infectious arthritis Krida (18) reviews the manner in which a joint may become infected - from external trauma, extension from an adjacent osteomyelitis, and hematogenous from a distant focus. The infection consequently may involve primarily the synovial membrane, as is most common, or by extension from an adjacent bone focus. The symptoms of pain, fever, swelling tenderness and limitation of motion develop in the first 24

to 48 hours. Its subsequent course is dependent upon the virulence of the organism and the resistance of the patient. Treatment is directed toward rest of the joint, aspiration or adequate drainage, identification and control of the infective agent, general supportive measures, local physiotherapeutic measures, and the prevention of deformities.

Bach (19) reviews the specific forms of infectious arthritis and reminds us that arthritis in brucellosis infections may be due to the (1) caprine, (2) the porcine, or (3) the bovine type, which are listed in the order of their virulence. The average course of fever is six to eight weeks, although it may last for twelve weeks. Bed rest, sulfonamides, brucellin and typhoid bacteria are proposed for treatment. He states that arthritis is reported to occur in 1.7 per cent of cases of scarlet fever and is more common in older children developing between the fourth and tenth day. It involves the smaller joints, lasting from two to five days. There is no specific treatment. He reminds us that arthritis may occur in about 5 per cent of children with congenital syphilis, either during the first month of life or between the ages of seven and fifteen years. He states that arthritis occurring during the secondary stage of syphilis is very rare while that occurring in the tertiary stage is more common due to gummatous formations. A Charcot joint may develop in tabes and usually only one joint is involved. Joint involvement may occur two to five days secondary to an infection with lymphogranuloma venereum which responds to sulfanilamide therapy.

Gonorrheal arthritis is reported to occur in about 3 per cent of patients developing gonorrhea and contrary to general belief initially is polyarticular in 75 per cent of cases, although following the acute attack it may subside and remain localized in one joint. However, it is pointed out by Bunim (20) that with the advent of chemotherapy gonorrheal arthritis is on the decline and its severity decreased. He agrees with Bach that at first it may be polyarticular, then monarticular with tenosynovitis. He states that it must be differentiated from (1) rheumatic fever in which the synovial fluid remains sterile and responds to salicylates, (2) rheumatoid arthritis, which does not respond to chemotherapy, and (3) Reiter's syndrome, which begins with a non-specific urethritis and arthritis, is self-limited, lasting from four to six weeks, leaving the joints undamaged. Pneumococcal arthritis is a rare condition, occurring about once in every 1,000 cases of pneumonia. According to Bunim the infections caused by the gonococci and the pneumococci have some things in common, in that they both originate from a remote focus and travel by way of the lymph and blood vessels to reach the synovial membrane and invade the joints, and both organisms are sensitive to chemotherapeutic agents. This last consideration has made arthrotomy unnecessary.

Bach also describes a type of polyarthritis associated with fever, a morbilliform rash due to the organism Haverhillia multiformis, which may be recovered from the blood or synovial fluid. The attack of red swollen joints may last for several weeks and the cases usually respond to neoarsphenamine.

In his discussion on tuberculous arthritis Balensweig (21) states that any chronic monarticular involvement at any age period should be suspected as being tuberculous, although it is more frequent in children and is a local manifestation of a general disease. He reports Nathanson and Kahn's study, which revealed that 42 per cent of children and 55 per cent of adults are suffering from some form of pulmonary tuberculosis, and Colombani and Webster in another study report 50 per cent of the cases show urinary involvement. It frequently involves more than one joint as demonstrated in

25 per cent of the adults and 35 per cent of the children in a cited review of 200 cases of bone and joint tuberculosis by Nathanson and Kahn. He describes the early stages of tuberculous joint disease beginning near the end of the long bone close to the epiphyseal line. The bone tissue is slowly destroyed, but there is very little skeletal reaction as occurs with other bone infections. It finally breaks through into the joint and spreads rapidly into the soft tissues. The clinical manifestation, consisting of pain, stiffness, weakness, atrophy and deformity, are described in general, and then he individually reviewed the pathology, clinical course, differential diagnosis, treatment and prognosis of tuberculosis of the spine, hip, knee, sacro-iliac joint, elbow, shoulder, wrist and ankle.

A case of bilateral purulent sternoclavicular arthritis, due to *Proteus vulgaris*, secondary to an umbilical infection, in a new-born girl was reported by Bogdanovitch (22). The case was successfully treated with sulfadiazine and penicillin.

Steinberg (23) discusses *Brucella abortus* infections and reports a case of sacro-iliac arthritis due to brucellosis in a 30-year old veterinarian. He studied a possible correlation between brucellosis and rheumatoid spondylitis in twenty cases and concluded that none existed.

Reiter's syndrome, a name applied to the symptom complex of a non-specific urethritis, arthritis and conjunctivitis is discussed by Wiggers (24) and Jones and Seid (25). Each presented two cases of the condition, which was first described in Germany by Reiter in 1916, who thought it was due to *Spirochaeta forans*. This has not been confirmed and the etiology remains unknown. Beiglbock believed it to be an allergic manifestation; others believe it to be of infectious origin. *Staphylococcus*, *enterococcus*, filterable virus and pleuropneumonia-like organisms have been suspected as the causative agent. The portal of entry is unknown. Jones and Seid state that the symptoms usually begin with a diarrhea followed by urethritis, conjunctivitis and arthritis and that the symptoms usually subside in the same order. About 25 per cent of cases have recurrences. The prognosis is good and no fatalities have been reported. According to Wiggers the conjunctivitis is present in less than half of the cases. In about 10 per cent of the cases a keratosis develops. Balanitis also occurs. Microscopic study of the synovial membrane revealed an intense inflammatory reaction of the superficial layers only with villi in which a great many capillaries are greatly dilated and marked lymphocytic infiltration.

Two additional cases are reported by Willcox (26) in 41 and 47 year old males, each of whom had a previous urethritis, one gonococcal and the other unconfirmed twelve years before. In spite of treatment with penicillin and sulfadiazine the triad of symptoms developed with well marked keratosis on the penis. One case was treated subsequently with oral potassium citrate and the other with three intramuscular injections of 5 cc of his own blood. Both cases ultimately recovered without specific drugs or fever therapy on a more or less ambulatory basis.

A case of polyarthritis with raised, scaly, erythematous lesions around the pubis and groin, smaller scattered lesions on the arms and trunk, and ulcerated and crusted areas on the toes with thin, brittle nails, was reported by Wigley (27) in a 42 year old male. There was no urethral discharge,

although he had suffered from gonorrhea, followed corneal ulcers and transient polyarthritis eleven years previously. Several discussors of the case varyingly regarded it as a case of rheumatoid arthritis, Reiter's syndrome and psoriatic arthritis.

An additional case is reported each by Quintin and White (28), Masters (29) and Florman and Goldstein (30). The former is a 41 year old male who failed to respond to penicillin therapy. Master's case was in a 30 year old male who he states responded favorably to mapharsen in conjunction with salicylates and physiotherapy. Florman and Goldstein's case was in a 4 year old boy who, following a short period of diarrhea, developed urethritis, conjunctivitis and arthritis. Attempts to recover a pathogenic organism were unsuccessful. A very interesting observation was high titre of S. Flexner VII agglutinins, which fell from a level of 1:1, 280 shortly after onset to 1:40 several weeks later.

Lahiri (31) states that most non-specific urethritis proves to be Reiter's disease, which is a syndrome consisting of non-specific urethritis, conjunctivitis and cutaneous lesions. (Ed. Note - Arthritis is usually considered a part of the triad whereas cutaneous lesions appear in only 10 per cent of cases.) He mentions a case of subclinical pellagra with a non-specific urethritis and conjunctivitis, which failed to respond to penicillin and which completely recovered in about two to three weeks on Vitamin B-complex therapy. He postulates the possibility of a Vitamin B-complex deficiency as an etiological factor of Reiter's syndrome.

In a review of the literature on acute rheumatism during the years 1939-1945 Perry (32) notes a decline in the death rate in the British Isles from this disease which roughly parallels the fall in the death rate of streptococcal infections. A similar trend is reported in the United States. The widespread practice of tonsillectomy may have had some influence according to Hedley. The age incidence is reported to be between five and ten years and rarely after twenty years for the first attack. Females are slightly more affected than males. A seasonal incidence is noted, which is highest in April and November. A strong familial incidence is noted, and he refers to a family reported by Pickles, (1943) in which of 53 descendants of a man with rheumatic heart disease, 23 had rheumatic fever or rheumatic heart disease. He remarks that both heredity and environmental factors may be involved. Income and density of the population is also reported to have a definite influence on the incidence and mortality rates. The interest in a virus cause of acute rheumatic fever has declined. The antistreptolysin titre is reported to be higher in children with, or who have had, rheumatic fever than in normal children. He refers to the work of Clawson (1940) who studied 796 post mortem cases of rheumatic heart disease and who pathologically distinguishes four types or phases of the disease: (1) acute rheumatic endocarditis (2) recurrent rheumatic endocarditis (3) valvular deformities, and (4) adherent pericardium. Three quarters of the cases fall into the third group. The work of Baggenstoss and Rosenberg, Fingerman and Andrus, Bayles, Bennett, Young and Schwedel, Hall and Anderson are quoted with reference to the findings of cardiac lesions identical with those found in rheumatic heart diseases in cases of rheumatoid arthritis. (Ed. Note - This is indeed a very interesting observation and requires further study.) Clinical features of the disease were usually preceded by some illness, although not always streptococcal. He suggests that this illness may lower body resistance to the rheumatic infection. That abdominal pain is often an early symptom

has been reemphasized by Langman (1941), Berger (1945), Davis and Rosin (1944) and Jones (1944). He refers to the work of Hayes and Gibson (1942) with reference to the significance of subcutaneous nodules and also to that of Struthers and Bacal (1942) who suggest that their occurrence probably indicate recovery from the present attack, however, a poor ultimate prognostic sign. The sedimentation rate continues to be the best indication of activity of the disease. It is reported that about 50 per cent of cases recover without permanent cardiac damage and those cases with acute carditis have a poor prognosis. He cites the work of Gubner and Szucs (1945) who found ascorbic acid more effective than sodium bicarbonate in the reduction of the toxic effects of salicylates and that calcium double salt of benzoic acid and succinic acid benzyl ester gave better results than salicylates. Many enthusiastic reports of the efficacy of sulfanilamide as a prophylactic measure are quoted.

Griffith (33) in a discussion on the newer concepts of rheumatic fever points out that rheumatic fever is currently being considered one of the collagenous diseases along with rheumatoid arthritis, periarteritis nodosa, lupus erythematosus, dermatomyositis and scleroderma. He considers rheumatic fever a systemic, post streptococcal, nonsuppurative, inflammatory disease of a hypersensitive nature with protean manifestations of unpredictable severity and duration. The syndromes differ one from the others of the group largely through the particular tissues involved and not because of any distinctive histologic picture. He presents evidence to show that acute rheumatic fever is a contact disease which is frequently associated with beta hemolytic streptococcus infections of types 6; 14; 17; 19; or 30. The anaphylactic nature of the disease is stressed. He recommends the use of salicylates early in the treatment of rheumatic fever in order to block the hypersensitivity reaction. He cautions against the use of sulfonamides and penicillin in the treatment of rheumatic fever because they increase the state of hypersensitivity and thus increase the severity of the disease.

Klemperer (34) recognizes the widespread implication of the connective tissue in the collagenous diseases and the possible significance of allergy in the causation of fibrinoid collagen alteration in these diseases. He is, however, reluctant to accept this allergic etiology solely on the histological features, especially since the classical manifestations of allergy are absent in the clinical course of these diseases.

Peterman (35) has postulated that the connective tissue alterations, as well as the deleterious effects of focal infections and toxicity in general in rheumatic diseases, might be manifestations of an acute or chronic glycuronic acid deficiency associated with one of natures many protective mechanisms. He conducted toxicity tests of glycuronic acid salts in dogs and in one human without deleterious effects and then treated 52 arthritic patients with reported good results in all but eight cases.

Discussing the etiology of acute rheumatic fever Gordon (36) relates that attempts to prove a bacterial etiology for acute rheumatic fever have been futile. He believes that a virus is the etiological agent and presents experimental evidence to support his views.

Following a prolonged period of bed rest for the treatment of acute rheumatic fever Roche (37) has observed that upon resumption of physical activity a number of patients had arthralgic complaints which upon investi-

gation proved to be unrelated to the attack of acute rheumatic fever. These cleared up with proper orthopaedic treatment.

Two cases of pregnancy complicated by acute rheumatic fever who died following delivery are reported by McKeown (38). She studied six other cases of mitral stenosis in pregnancy in which the patients died from cardiac failure. Microscopic evidence of recurrent rheumatic carditis and valvulitis was present in her two cases and in five of the six cases studied she concludes that: (1) Rheumatic heart disease even in its severest form may occur subclinically, (2) Recrudescences of rheumatic fever during pregnancy in a patient with a known cardiac lesion may not infrequently be the factor responsible for cardiac failure, and, (3) The patient with active rheumatic carditis may die quite suddenly following delivery, the condition simulating acute obstetric shock.

According to Rosenblum (39) the diagnosis of acute rheumatic fever is inadequate unless it includes the concept of activity or inactivity. The various manifestations of rheumatic activity are reviewed and are grouped in the order of their significance: (1) Activity positive, - carditis, including electrocardiographic evidence, nodules, erythema marginatum, chorea and polyarthritides, (2) Activity probable, - arthralgia and myalgia, pneumonitis, acute bronchitis, acute pleurisy, increased sedimentation rate and reduced vital capacity, and (3) Activity suspected, - fever, weight loss, abdominal and chest pain, rapid pulse, anemia and leukocytosis.

Bach (40) in his recent edition of "Arthritis and Related Conditions" defines rheumatoid arthritis as a systemic disease whose etiology is unknown, but believed by some to be of infectious origin and in which a chronic progressive, nonsuppurative, deforming polyarthritides is the most apparent manifestation. The symptomatology is reviewed, the pros and cons of the infectious theory are summarized, and the influence of psychic distress, fatigue, hormones, nutrition, anemia, trauma, climate and constitutional background in the development of arthritis are discussed. He summarizes: "Rheumatoid arthritis notoriously strikes the asthenic usually in the twenties, who is poorly nourished and overly anxious, (young, tense, and skinny), who have been exposed to fatigue, psychic or physical trauma, bad diet or other secondary factors either alone or in combination."

In an excellent description of rheumatoid arthritis and rheumatoid spondylitis Boland and Headley (41) consider both conditions to be variants of the same disease for which gold is the best treatment in the former and x-ray therapy the treatment of choice in the latter.

That rheumatoid arthritis may be precipitated by a gonorrheal infection is demonstrated in a case presented by Bock et al (42) of a 29 year old male who developed polyarthritides two weeks following a gonococcal urethritis. The urethritis responded to penicillin therapy, but the general condition and arthritis did not, but rather progressed to manifest the findings observed in rheumatoid arthritis.

Kelly (43) points out that rheumatoid arthritis can be precipitated by an injury to a single joint. He reviewed the literature on the subject and presented ten additional cases. He refers to another 34 cases to show a striking preference for symmetrical patterns and suggests that the constitutional factor that favors the spread of the disease is a transient rather

than a permanent condition of the organism.

A study of the psychosomatic cause of rheumatoid arthritis was made by Johnson, Shapiro, and Alexander (44). Since the psychic factors are found so commonly in patients who do not suffer from arthritis, they conclude that additional etiologic factors still unknown must be postulated.

Three cases of rheumatoid arthritis who developed lung lesions in the early active phase of the arthritis are presented by Ellman and Ball (45). Two of these cases came to autopsy and revealed evidence of fibrosing pneumonitis. They believe the lung lesions to be clinical manifestations of a generalized disease for which they propose the term "Rheumatoid Disease."

Kersley and Desmarais (46) report that lesions have been discovered in rheumatoid arthritis which occur in any or all muscles of the body at any stage of the disease. They are also found in synovial membrane, the fibrous tissue stroma of fatty tissue and around the peripheral nerves. In about 100 biopsies the histological picture has not been seen in any other than rheumatoid, non-specific, infective, or atrophic arthritis. They state that these nodules, though similar to those seen in rheumatic fever, can microscopically be distinguished with considerable certainty.

The characteristic necrobiotic nodules were found in the larynx, muscles, subcutaneous tissues, peritoneum, lungs, pleura, pericardium and myocardium of a 62 year old female with rheumatoid arthritis by Raven, Weber and Price (47).

The observation that subcutaneous nodules in acute rheumatic fever denotes a grave prognosis lead Lucchesi and Lucchesi (48) to study the significance of subcutaneous nodules in 55 cases of rheumatoid arthritis. They concluded that, contrary to the observations in rheumatic fever, the nodules in rheumatoid arthritis do not indicate an unfavorable outlook, any involvement of the heart, or any enhanced activity, intensity, or severity of the arthritis, and that they do not constitute any obstacle to treatment.

In a study of 68 cases of periostitis of the os calcis Fang (49) found that 73 per cent of them were suffering from rheumatoid arthritis. He considered the pathological findings of bone destruction and proliferation comparable to that observed in Marie-Strumpell-disease. He concluded that periostitis of the os calcis in Chinese is not a separate entity, but an osteoperiosteal manifestation of rheumatoid arthritis. (Ed. Note - Many patients with rheumatoid arthritis complain of soreness about the heels. X-ray examination reveals the irregular areas of bone destruction and proliferation as described in this article. Recently I have observed a periosteal reaction on the lateral surface of the middle third of the left radius in a patient with rheumatoid arthritis. Microscopic study of a biopsy revealed the picture of an inflammatory process with thinning of the bone trabeculae and the marrow spaces filled with fibroblasts and lymphoid cells.)

Bywaters (50) noted the radiological similarity between rheumatoid arthritis and pulmonary osteoarthropathy. He postulates that the periosteal changes may be due to the presence of an inflammatory edema with a high protein content. Periosteal changes were not observed in cardiac and renal edema where the fluid protein was below 1mg per cent.

Granirer (51) studied the prothrombin time of fifteen patients of rheumatoid arthritis treated with gold (Solganol B) and liver extract for one year to determine if Vitamin K would be indicated, assuming liver damage due to gold. No increase in the prothrombin time was found.

Unger, et al (52) believe that amyloidosis occurs as a complication of rheumatoid arthritis more frequently than generally believed. They report ten cases, four post mortem and six living out of 58 and 52 patients respectively. Prior to this only 40 cases have been reported. Hill (53) added another case.

The importance of an adequate history, a thorough physical examination, with a few well chosen laboratory investigations, principally the sedimentation rate and x-ray studies in the differential diagnosis of the arthritides have varyingly been discussed by Kinsella (54), Bach (55), (58), Goldfain (56), and Collins (57), Seth-Smith (59) and Godfrey (60). Seth-Smith and Godfrey strongly recommend the use of the standard hand radiograph as described by S. Gilbert Scott for the evaluation of arthritis.

A study of rheumatoid arthritis in children was made by Edstrom (61) in 65 patients and Pickard (62). Pickard studied the records of about 200 children suffering from rheumatoid arthritis of which 35 were followed long enough to observe the end results. They observed that the condition occurs not infrequently. About 5 per cent of all rheumatoid arthritis seen, as reported from several clinics, are under the age of 15 years, especially during the second and third years. Only three of Edstrom's and five of Pickard's cases displayed the clinical picture as originally described by Still with arthropathy, adenopathy, splenomegaly and hepatomegaly. Girls (71 per cent) were affected more often than boys (29 per cent) in Edstrom's series. This sex difference was not so pronounced in Pickard's cases. The onset of rheumatoid arthritis in children differs from that in adults in that the larger joints are more often attacked. The lower extremities are involved most frequently, particularly the knees. Infection, trauma and allergy seem to play an inciting role. Heredity may play a part. The process frequently begins as a monarthritis, a factor responsible for many mistaken diagnoses. Visceral lesions occur more frequently than generally recognized. A moderate elevation of the sedimentation rate, a moderate hypochromic anemia and eosinophilia were observed. A tendency to flexion contractures is often marked, requiring physical therapy to keep the joints moving and orthopaedic measures to prevent and correct deformities. Rest and hospital care is a necessary part of treatment. The prognosis appeared relatively good in all cases except those of typical Still's disease. The average duration was from two to three years for those considered cured.

A case of chronic polyarthritis in an eight month old male is reported by Tho (63). Only eight other cases of this disease under the age of one year have been found in the literature. Another case of Still's disease in a ten year old male was reported by Grieve (64). This case was considered unusual because of a finding of polydactylitis with negative evidence for tuberculosis and syphilis. Two additional cases of rheumatoid arthritis with associated cardiac involvement, in males age 4 1/2 and 5 1/2 years, were reported by Glick (65). The cases are discussed indicating the diagnostic problem posed by these two cases. (Ed. Note - These cases represent additional instances of visceral manifestations in rheumatoid arthritis in children.)

Ankylosing spondylitis is discussed by Kuzell (66) and Rees, Albers and Nichols (67). The features of the disease are summarized. The etiology is unknown. It begins as an atrophic arthritis and secondarily there is ossification of the adjoining ligaments. It involves the apophyseal articulations of the spine, the sacro-iliac joints, and sometimes the hips, shoulder and peripheral joints. The costovertebral joints also become involved. An antecedent genito-urinary infection may be a factor. Spondylitis occurs more frequently in females than generally believed. It is a disease of the young and active. The history of the patient reveals the presence of intermittent back pain or hip pain dating from childhood. The diagnosis is usually not made until the third or fourth decade. There is a marked elevation of the sedimentation rate and a moderate secondary anemia. The spinal fluid occasionally shows an increased protein content. X-ray changes are divided into three stages, the first stage of pseudo-widening of the joint space, the second stage pyknotic formation in the joint area, and the third stage loss of joint space and synostosis. Great symptomatic relief can be obtained from the proper use of X-ray therapy in conjunction with bed rest, braces, supportive jackets, repeated transfusions of whole blood, physiotherapy, deep breathing exercises and nutritious diet. The differences between this condition and rheumatoid arthritis are noted. Kuzell suggests research to determine the culpability of virus as an etiologic factor. Of the 120 patients treated with X-ray therapy reported by Rees, et al, 80 per cent were improved. About 50 per cent noted improvement during the course of radiation therapy. Roughly 20 per cent of the 80 per cent improved had recurrences within one year.

Douthwaite (68) states that in view of the difference in sex incidence, characteristic bone changes and response to chrysotherapy as observed in his series of 692 cases of rheumatoid arthritis and 36 cases of ankylosing spondylitis, he is unable to agree with those who regard the two conditions as one and the same disease. This view is also held by Buckley (69) who feels that the tendency of many to consider that ankylosing spondylitis is simply rheumatoid arthritis affecting the spine has done much to retard progress in its study and to mask some of its most important characters. He believes that the disease begins in the bones and not in the joint tissues and that it is an infective or toxic osteopathy which may occur in two different forms of ankylosing spondylitis, the one described by Gilbert Scott as adolescent spondylitis and another which begins at a later age.

Desmarais (70) studied 24 cases of ankylosing spondylitis and found no correlation between the acid and alkaline phosphatase and the activity or duration of the disease in years.

Some orthopaedic aspects of ankylosing spondylitis are discussed by Capener (71). He advocates physiological rest, particularly on the Bradford Frame for part of the day alternated with activity until symptoms subside. Surgically osteotomy of the spine as described by Smith-Petersen may correct some of the spinal deformity. To restore motion of the hip various reconstructive procedures are available; these include Whitman's reconstruction, Colonna's operation, Girdlestone's hip excision, Jones subtrochanteric pseudoarthrosis and Smith-Petersen's mold arthroplasty. One case is reported by Snow. (72)

Appelgren (73) reports four cases with intermittent swellings and pains

in various joints with allergic characteristics. He suggests that the patient's present state could be a hyperergic phase in a chronic rheumatic condition of allergy. They may represent a transition between pure allergic arthritis and a usual chronic polyarthritis.

A discussion of palindromic arthritis is given by Gryboski (74) and Wolfson and Alter (75) each present a case. They summarize the condition as a syndrome of acute arthritis, peri-arthritis and para-arthritis that recurs in multiple, irregular, usually febrile attacks, and leaves no recognizable residuals in the affected joints. Routine laboratory tests are within normal limits. Cholesterol and total lipoids are commonly elevated as is the sedimentation rates made during the attacks. The etiology is unknown, although allergy and psychic upsets have been suggested. Wolfson and Alter's case was in a 42 year old white female who had in four months 34 attacks of pain, tenderness, redness, swelling and stiffness of multiple joints. The attacks reached their height in from one to two hours and subsided promptly within three to twenty-four hours. Gryboski's case occurred in a 33 year old white female who had had erythema nodosum three years previously and extrapulmonary tuberculosis which had been treated with streptomycin. She presented the typical syndrome described by Hench and Rosenberg with a marked red nodular eruption over the acutely painful, tender and swollen joints. There were multiple attacks. The sedimentation rate was elevated as were the blood cholesterol and total lipoids. X-rays revealed no changes. She was treated with slow intravenous drip of histamine and acid phosphate with relief of symptoms.

An analysis of the literature on the etiology of fibrositis has been made by Valentine (76) which reveals that there is no unanimity among the many authors on the subject. He summarizes by stating that fibrositis seems to be a tissue reaction of varying pathology to several factors, largely from mechanical and physical and sometimes toxic causes. Some defect of circulatory functional response, probably in the peripheral reflex arc, may render the individual more liable to fibrositis.

Scott (77) believes that some sort of infection is the cause of the formation of the fibrositic nodules. He considers the nodule a rheumatic scar in muscle which aches and burns with changes in weather as do other scars. He reports beneficial response to the local injection of essential oils, such as 3 per cent solution of benzyl salicylate in olive oil or Arachis oil, into the area of fibrositic activity.

Benians and Russell (78) disagree with Dr. James Cyriax that symptoms commonly attributed to primary fibrositis are really caused by derangements of the spine.

Osteoarthritis, one of the most prevalent rheumatic disorders, is discussed by Bach and Waine (79), (80). They describe three pathological changes occurring at the same time; (1) degeneration of the cartilage, (2) hypertrophic changes at the articular margins, and (3) condensation and increased calcification in the subchondral bone and inconstantly the synovia undergoes chronic hyperplasia. The changes usually begin in the second and third decade of life and the alterations are irreversibly progressive with advancing age and become nearly universal in both sexes. The etiology is unknown; however, there are a number of predisposing factors. The highest morbidity develops in patients of the fourth and fifth decades and more often in females.

than males. The clinical manifestations decrease in frequency during late life.

Hall, Wade, et al (81) see the relief of pain as the main objective in the management of osteoarthritis rather than restoring painless movement.

Osteoarthritis of the cervical spine which simulated coronary artery disease is reported in 43 patients by Davis and Ritvo (82).

In an extensive study on Heberden's nodes, a clinical characteristic of osteoarthritis of the fingers, Stecher (83) concluded that two conditions are necessary for their development. The first, a hereditary susceptibility, and secondly, a normal nerve supply to the hands and fingers. Other factors which seem to be secondary, include race, age, and menopause, according to Stecher and Beard (84). Stecher (85) points out that the practicing physicians should have a knowledge of the pathogenesis, occurrence, clinical signs, symptoms and futility of treatment of Heberden's nodes so that he can explain their significance to his patients. He will thereby be able to reassure his patients that although they have arthritis they have the mildest, least disabling and most painless form of the disease.

Chronic idiopathic hypertrophic osteo-arthropathy first described by Sternberg in 1899 as a separate entity and elaborated on by Oehme (1919), Gronberg (1927) and others is reviewed by Camp and Scanlan (86), who report five cases. The etiology is unknown. It is not associated with primary diseases and occurs predominantly in males at puberty. It is characterized by clubbing of the digits, enlargement of bones and joints and thickening of the skin of the face. Its course is slowly progressive to deformity and disability, often extreme.

Waxman and Geshelm (87) report the occurrence of 22 injuries to the knuckles out of 523 injuries to professional and amateur boxers. In 12 of the 22 cases the diagnosis was contusion. In the remaining 10 cases a diagnosis of bursitis was made and confirmed by aspiration. Seven responded to conservative measures and three required excision. They reviewed the literature on 27 cases which occurred in a variety of occupations. In each instance it was considered post-traumatic.

A discussion of gout is made by Bach (88), Myers (89), and Hagemann (90), Sacasa (91), and Lindley and Middleton (92), who summarize the condition in which there are sudden attacks of pain in joints which usually occur at night. The first attack usually occurs in the great toe (60 to 70 per cent) in men (95 per cent) after the age of 40 years. There is rapid increase to maximum disability with a hot, bluish, red, edematous joint. The attack ends abruptly and is followed by pain free intervals, then by other attacks, eventually ending up as a chronic disease. Heredity is a predisposing factor. Trauma, infection, drugs, ketogenic diet and psychic disturbances are precipitating factors. It is associated with a high blood uric acid figure. Hagemann states this is due to increased urate formation. Sodium urate crystals are deposited in various tissues with resulting inflammatory and degenerative changes in about 50 per cent of cases. Punched-out areas appear in bone which Bach states can be differentiated because of size from rheumatoid arthritis. (Ed. note - The x-ray picture in gout is not pathognomonic.)

Olecranon bursitis, Achilles tendinitis and renal colic (10 to 30 per cent) are not infrequent manifestations. The chronic phase of gouty arthritis becomes established when residual joint abnormalities develop. This may be two to twenty years after initial attack. The disease occurs more frequently than generally believed. The diagnosis is aided by history, elevated blood uric acid level, x-ray changes, satisfactory response to colchicine and confirmed by the demonstration of urate crystals from tophi. Lindley and Middleton report a case in a 32 year old male.

A case of unusual rapid progress in a male age 23 years is reported by Kersley (93). Another case in a 36 year old male with multiple severe joint involvement and many features of rheumatoid arthritis is reported by Read and Buxton (94). Ankylosis developed in many joints. Later examination of bursae revealed urate crystals. The patient was treated with colchicine, orthopaedic surgery and physiotherapy with a return of function and ambulation.

Horwitz (95) suggests that the presence of bone and cartilage debris in the synovium is a possible indicator of the early evolutionary stage of a neuropathic joint.

A case of painless joint disease with the x-ray picture of a neuropathic joint in a patient with severe pernicious anemia, observed by Halonon and Jarvinen (96) caused them to study 52 other patients with pernicious anemia in which the test for syphilis was negative. They observed changes in joints, particularly in the knees. They considered the joint changes to be both clinically and radiologically of the type of neuropathic arthropathies.

Spear (97) reports the development of a neuropathic knee joint seven years after the onset of diabetes in a 62 year old male in whom tests for syphilis were negative.

A charcot joint secondarily infected by *Staphylococcus aureus* in a 64 year old male which failed to respond to intramuscular injection of penicillin was successfully treated by intra-arterial penicillin by Shaffer (98). The technique is described.

A case of arthropathic psoriasis is reported by Senear and Griffith (99) in a 30 year old white male. Episodic stiffness and pain had occurred in multiple joints for fourteen years. For the past five months hyperkeratotic cutaneous lesions had been present on the tips of the fingers, toes and extensor surfaces of the elbows.

Psychogenic rheumatism is discussed by Boland (100), (101). He states that physicians in general are not familiar with the fact that disabilities of the locomotor system frequently result from psychic causes. These are not infrequently diagnosed as arthritis and so treated by physicians who in so doing foster rather than alleviate the disability. He does not believe that mental disease is the cause of arthritis but may act as a precipitating factor. In a study of precipitating factors in 100 soldiers with rheumatoid arthritis an emotional upset was considered as a possible factor in only one instance. He defines psychogenic rheumatism as the musculoskeletal expression of functional disorders, tension states or psychoneurosis. He reports an

incidence of 14.6 per cent in 7,000 cases of arthritis as seen in an Army rheumatism center during the war where it was second only to rheumatoid arthritis as a cause of admission. The diagnosis depends on: (1) absence of organic disease or insufficient disease to account for the disability, (2) qualitative functional characteristics of the disability, and (3) positive diagnosis of psychopathology. The differential diagnosis most frequently must be made from primary fibrositis.

Wright (102) also points out that psychogenic arthralgia will be diagnosed more frequently and treated more satisfactorily if physicians are alert to its existence. He reports two cases of widely different character requiring different forms of treatment.

CLINICAL INVESTIGATION

A study of the agglutination test with hemolytic streptococci groups A, C and G, in 241 cases of rheumatoid arthritis with 80 per cent positive agglutination and in 900 control patients with a very low per cent of positive agglutination is made by Kalbak (103). In the control group of the cases of rheumatic fever 10 per cent gave positive agglutination, a high incidence per disease incidence in this group. He believes that the hemolytic streptococcus plays a dominant etiological role and that the reaction is an expression of chronic infection by hemolytic streptococci and is induced by a labile surface antigen (Y). The reaction reveals interesting points of resemblance between rheumatic fever and rheumatoid arthritis.

Bertrand, Waine and Tobias (104) studied the distribution of gold in the animal body by using a gold radioactive isotope in rats and rabbits. They found that the gold was taken up by various tissues of the body, including the central nervous system and ocular structure of the rabbit. It was taken up most markedly by the kidney and spleen. The time interval following injection had little to do with the values of any given tissue, which would seem to indicate that gold is held rather firmly by the respective tissues once it has left the blood stream. The amount excreted after the fourth day is small. They found that the amount of gold taken up by chemically inflamed tissue in a chemically produced arthritis was significantly higher than in normal tissue. The same findings were noted in the inflammatory wall of a chemically produced abscess in muscle. The experiment was performed on one human arthritic patient where the synovium took up eighteen times as much gold as the skin which would compare to the values obtained for rat kidney.

A study of the in vitro respiratory effect of gold salts on rat kidney by Block, Geib and Robinson (105) revealed that the in vitro inhibition of oxygen consumption with gold sodium thiosulfate is not lessened by the potential thiol compounds, cystine and methionine, nor by BAL or thiomalic acid which contain thiol groups; however, sodium thioglucose does lessen the inhibition of oxygen consumption. The effects of BAL and thiomalic acid may be marked by the fact that they, in themselves, produce inhibition of respiration. The inhibition of oxygen consumption by gold chloride is appreciably reduced by thiomalic acid, BAL, cystine and sodium thioglucose, but not by methionine or cystine. When three thiol groups are furnished for each atom of gold, the reduction of inhibition is more clearly shown than when only one thiol group per atom of gold is present.

A study of the use of polarized light on the fibrillar system of cartilage in arthritis deformans was made by Lugiato (106) and compared with the use of ordinary stains. This fibrillar system is the supporting framework of cartilage, the early weakening of which indicates loss of cartilaginous elasticity. Loss of elasticity is followed by erosion, marginal proliferation and in the later stages by invasion and replacement of cartilage by fibrous tissue. The degenerative process begins with the alteration of the fibrillar system of support. Degeneration increases with further alterations in the fibrillar system and ends with the destruction of the joint surface. A study of the changes in this fibrillar system is essential to an understanding of the changes characteristic of arthritis deformans, which has been made possible and readily carried out by the use of polarized light whereas it is difficult or impossible by other means. Polarized light can readily be used and is recommended in the study of the fibrillar system in other pathological conditions.

Based on the belief that increased hyaluronidase activity is a possible cause of the breakdown of interfibrillar cement in rheumatic diseases and that high concentrations of salicylates in vitro inhibit hyaluronidase, whereas low concentrations of the biological oxidation product of salicylate, gentisic acid inhibits hyaluronidase, Meyer and Ragan (107) employed sodium gentisate in rheumatic patients and found uniformly the same antirheumatic effect as salicylate without some of the disadvantages.

Routti (108) studied the circulation in the forearm of eight healthy persons and eighteen persons with rheumatoid arthritis with the help of an air plethysmograph. He found very great individual variations in the peripheral circulation in healthy individuals. The peripheral circulation of patients with rheumatoid arthritis had approximately the same rate as that of healthy individuals in a limb where there were no inflamed tissues, but was accelerated in those with inflamed limbs.

Bartter, Forbes and Albright (109) found from metabolic studies that the administration of adrenocorticotrophic hormone (A.C.T.H.) to patients with panhypopituitarism, acromegaly, osteitis deformans, and ovarian agenesis causes elaboration of an adrenal cortical hormone which inhibits the production of bone matrix by osteoblasts.

Beneficial clinical effects with repeated blood transfusions are reported by Appelquist and Holsti (110) in 24 patients with severe rheumatoid arthritis. They recommend that it should be used before gold therapy in the routine treatment of this disease. They observed a general clinical improvement with a feeling of well being and increased mobility of the joints. When reactions due to transfusions occurred the improvements were most remarkable. The sedimentation rate is decreased and the hemoglobin values increased. They suggest that there may possibly be some antirheumatic factors in the plasma of healthy individuals.

Simpson and Brooks (111) studied the effect of blood transfusions of whole blood, concentrated red cells and plasma on the blood picture and general condition of patients suffering from rheumatoid arthritis. They found that the majority of rheumatoid patients had a normal total protein, a high fibrinogen, a normal albumin and a normal globulin value with a normal A/G ratio. Following transfusion with packed cells and whole blood those

cases which showed abnormal protein values initially became normal. One of the cases returned to an abnormal value after one month. The remainder maintained normal values for the one month period of observation. Some cases which were normal before transfusion became abnormal fourteen days after transfusion and a few with normal plasma proteins remained unchanged. Two cases transfused with plasma alone had normal figures before and after transfusion. They intend to study the effect of plasma alone on abnormal plasma readings. Blood transfusions resulted in a rise of the hematocrit and hemoglobin values. The crude and corrected suspension stability improved temporarily with the lessening of anemia and improvement of the plasma protein picture. At the same time the general condition of the patient improved markedly even though no immediate objective improvement was noted in the joints. They plan further studies to determine what constituents of blood is responsible for the improvements noted.

TREATMENT

A review of the literature published in 1948 and written at this time is, of course, out-dated in many respects due to important and far-reaching advances in therapy and in clinical investigation in the field of Rheumatology. It was during the latter part of 1948 that the initial work with "Compound E of Kendall", now known as Cortisone, was begun. It was also about that same time that other investigators began their work with ACTH or the adrenocorticotrophic hormone. Other hormonal preparations and steroid compounds naturally have been used rather extensively in clinical investigation, which is still continuing on an extensive scale. These newer therapeutic procedures are still not available for general use. It is, therefore, essential that the basic principles of therapy of rheumatic diseases, together with other therapeutic procedures of known value or of probable value, be understood. Treatment, therefore, is discussed under the various headings as follows:

A. Rheumatoid arthritis involving peripheral joints.

The management of these cases has been thoroughly discussed by Bauer (112), Norcross and Lockie (113), Wulp (114), Pinckney (115), Tegner (116), Bach (117), and Bayles (118). Essentially the basic program consists of:

1. Bed rest, including local rest for the involved joints and complete physical and mental rest of twelve to sixteen hours per day.
2. Psychotherapy.
3. Adequate analgesia afforded by aspirin or other salicylates, which is essential for rest and well being. It is well to remember the truism of Hench that "musculoskeletal pain that requires narcotics is not arthritis".
4. Directed exercises which are essential to improve and maintain muscle strength and tone and to maintain joint function.
5. Application of heat to actively involved joints which is beneficial in relieving pain and muscle spasm.
6. Proper support for joints allows reduction of muscle spasm and pain and prevents deformity. The prevention and correction of deformities are most important features in the treatment of rheumatoid arthritis. Meyer (119) warns that involved joints must not be kept in complete rest too long at a time lest periarticular adhesions and fixation occur. Active and assistive exercises must be carried out daily. Elastic pressure bandages favor resorption and are comforting while rigid plaster bandages favor immobilization and congestion.
7. An adequate diet, adequate in calories, proteins,

minerals and vitamins, is essential, and this may be supplemented by additional vitamins when indicated. Bower (120) recommends the diet suggested by Fletcher of Toronto, consisting of maintenance protein, relatively low carbohydrate and high fat, and where no gouty tendency exists nucleoproteins are liberally provided. This diet is supplemented by Vitamin B and wheat germ oil. Scully (121) discussed vitamin therapy in arthritis and concludes that vitamin therapy should be used only as an adjunct to other recognized methods of treatment. Concentrated Vitamin D in large doses has been reported as useful in some cases, but it is toxic and its routine use is not advisable. 8. Iron medication is useful in correcting the associated anemia, and whole blood transfusions are at times indicated and helpful. 9. Removal of foci of infection is indicated in helping to improve the general physical condition, but not with the idea of the procedure being a curative one.

In addition to this basic program, other therapeutic procedures are widely accepted and include: 1. Typhoid vaccine which is administered intravenously at regular intervals, a total of four to six injections or more being given. (Ed. Note - This procedure has been used for many years and in our experience is of decided value in many cases.) 2. Streptococcus vaccines and foreign proteins which are reported as of value in some cases. 3. Prostigmine given in injections of 1 cc of 1 to 2,000 solution or 15 to 30 milligrams orally three times daily seems beneficial in relief of pain in some cases. Toxic manifestations from neostigmine have been reported and satisfactorily treated by atropine sulfate. A well controlled series has demonstrated little or no real value of neostigmine in the treatment of arthritis according to Ford (122). 4. Electropyrrexia has been recommended as an adjunct to all other forms of treatment of arthritis rather than to the exclusion of other forms of therapy by Hales (123) in his discussion on this form of therapy. 5. Acid azo compounds (Salazopyrin), according to Svartz (124), produced beneficial effects in rheumatic polyarthritis, but his percentage of remissions and relief of symptoms was no more striking than the usual 60 to 75 per cent remission rate. 6. X-ray therapy was recommended by some authors in treatment of peripheral rheumatoid arthritis. (Ed. Note - Most authors agree as to its efficacy in rheumatoid spondylitis, but not in peripheral joint involvement.) 7. Autotransplantation of joint capsular tissue in an attempt to desensitize patients suffering from rheumatoid arthritis afforded favorable results in Novotny's cases (125), but here again critical analysis reveals no increased percentage improvement over other types of therapy. 8. Procaine or novocaine by local infiltrations sometimes afford temporary relief, according to Pinckney (115) and Lipkin (126). 9. Gold therapy was considered by many as the best single method of treatment, but it should be employed as an adjunct to treatment. Norcross and Lockie (113) claim improvement in 75 per cent to 80 per cent of their cases. Wulp (114) favors gold therapy as "one of the most outstanding" methods of treatment and recommends smaller doses over a longer period of time followed by maintenance or booster doses every four to six weeks. Parr (127) reports a "cure" in 10 per cent of his cases and improvement in 75 per cent with gold therapy. He used sulfonamides before or concurrently with gold and believed the combination to be efficacious. (Ed. note - Sulfonamides are not considered of benefit in treatment of rheumatoid arthritis.)

Brugsch and Manning (128) report definite improvement in 75 per cent of cases and "regression of activity" in 58 per cent. Cohen, Dubbs and Goldman (129) report subjective and/or objective improvement in 90 per cent

of their 475 cases and definite objective improvement in 64 per cent. Toxic reactions were encountered in 21 per cent of their patients and BAL was recommended upon the appearance of the first toxic symptoms. In 48 per cent of Snyder's cases reported by Bach (130), gold salt therapy has been found effective. Toxic reactions have occurred in 16 to 40 per cent of cases. AuroI sulfide (colloidal) is less toxic, but is less effective, and is not recommended. Better results are obtained when gold is given early, but less dangerous methods of treatment are recommended unless the risk is considered. Toxic manifestations of gold poisoning are, according to Bach (131), generalized erythema, aplastic anemia, purpura haemorrhagica, granulocytopenia, stomatitis, intestinal involvement, generalized hepatic impairment, edema, herpes, erythema nodosum, kidney impairment, multiple brain hemorrhages, etc. There is no warning period nor does there seem to be any relation between the amount of gold given and the severity of the ensuing reactions. These reactions may occur weeks, months or even a year after the last injection of gold. Kersley (132) states that gold therapy is still empirical, but when correctly administered to the selected case its beneficial effect greatly outweighs the risks. If gold cannot be continued, then other metals or vaccines may be tried, such as sodium bismuthyl tartrate, copper salts or Alcuprin administered intravenously or Dicuprene (Forestier) given intravenously or intramuscularly. The latter may cause slight dermatitis in some cases, but no other toxic signs.

Bayles (118) recommends that chrysotherapy be instituted before irreversible joint damage occurs, but that on the other hand the patient should not be treated with gold until after other routine treatment of known value has been instituted for from three to six months. BAL has proved effective in his cases in counteracting the toxic reactions due to gold salt therapy and is given by intramuscular injections in 0.15 milligram doses four to six times daily and reduced in two to three days to one or two doses daily.

Green and Russel (133) also found that gold dermatitis is satisfactorily relieved by the use of BAL, but following its use arthritic manifestations return promptly. Manifestations of tetany due to BAL therapy are probably due to depletion or unavailability of calcium or magnesium or both, according to them.

Wright (134) concurs with Bayles (118) and Green and Russell (133) in that the greatest benefit from chrysotherapy is derived by the patient with active rheumatoid arthritis, preferably in the early stages, and with the effectiveness and action of BAL in cases of toxicity. He lists the following contraindications to the employment of gold: History of purpura, agranulocytosis, renal or hepatic disease, pregnancy, hemophilia, severe diabetes mellitus, colitis, severe anemia or any hemorrhagic tendency, severe eczema or chronic dermatitis, severe bronchial asthma or any serious systemic disease other than rheumatoid arthritis or psoriasis.

The administration of gold should be combined with low grade fever therapy, 101⁰, for better distribution of the gold, and as an aid in elimination of untoward reactions, according to Drewyer (135). With this program he obtained 90 per cent "remissions".

Forms of therapy, although of questionable value, but which may be helpful according to Bach (117) are: Liver extract Bayles (118) states that

one-fourth to one-half pound of raw liver given daily in one-half glass of ginger ale, tomato juice or grapefruit juice is thought to be helpful in cases of amyloidosis and rheumatoid arthritis, arsenic, strychnine, dilute hydrochloric acid, quinine as an analgesic and tonic, thyroid or thyroid and pituitary extract in some cases and estrogens in some cases. He further states that proper elimination is important and may be aided by bland or bulky diets as determined by barium enema studies and that "mild laxatives or colonic massage and irrigations may not be amiss".

Forms of therapy considered to be of no value in the treatment of rheumatoid arthritis by various authors are: 1. Sulfonamides (Virkkunen (136)) 2. Iodine. 3. Sulfur. 4. Aluminum subacetate (Blazer, Friedman and Steinbrocker (137)) 5. Aurol sulfide. 6. Penicillin (Coss, et al (138) and Bach (139)) 7. Bee venom. 8. Cobra venom is useful only in cases of arthritis due to malignancy where it is useful in relief of pain. 9. Hyperthermia. 10. Streptomycin. 11. Neostigmine. 12. Reticular cytotoxic serum.

B. Rheumatoid arthritis of the spine or rheumatoid spondylitis. The general care of the patient is as important in spinal arthritis as in cases with peripheral joint involvement. Most of the recognized principles of treatment as discussed above apply equally in the case of the spondylitic. Adequate rest, a high caloric diet supplemented with vitamins, improving or restoring the patient's morale, the removal of foci, the use of aspirin or sodium salicylate in adequate doses for relief of pain and in obtaining required rest, deep breathing and postural exercises, which should be given three times a day, fracture boards used under the mattress, only a small pillow permitted, if at all, hyperextension carried out thirty minutes out of each day, artificial supports dispensed with unless absolutely necessary to maintain posture and X-ray therapy for controlling the pain are accepted principles of therapy outlined by Pinckney (115), Bach (117) and Toone (1140). The technique of X-ray therapy advocated by Smyth, Freyberg and Lampe in 1941 is the one most generally used. Gold is of no benefit. Concentrated Vitamin D and parathyroid preparations should not be used and will only lead to generalized osteoporosis and may result in pathological fractures.

Williams (1141) states that the original method of X-ray therapy of Dr. Gilbert Scott is now accepted as outmoded by a newer, more intensive therapy. The joints of the spine, the hips and shoulders, the ischial tuberosities, crest of ilium, sternoclavicular and costosternal joints are treated with alleviation of symptoms. Inflammatory tissue or granulation tissue is radio-sensitive and resolution can be induced by X-rays and muscle spasm is relieved. According to Borak (1142), (1143), in the early or first stage of the disease active motion is "reflexly" limited to avoid pain produced by inflammatory processes in the synovia. Small doses of X-ray, 50 r, are effective in this stage, and if this is not effective, it must be assumed that a more advanced stage is present and from 300 r up to 1200 r may be used within a period of two to three weeks.

In the second stage active and passive limitation is associated usually with narrowing of the joint spaces and some bone destruction. If a dose of 1500 r is given in a period of two to three weeks, pain gradually decreases, but if the dose is too small symptoms may relapse. "The extent of improvement is proportionate presumably to the destruction of granulation tissue."

In the third stage no active or passive motion is possible, but pain can be influenced by 1600 r given over a period of ten days. The percentage of favorable results increases in proportion to the dosage applied.

Williams (141) reminds us that X-ray therapy in spondylitis is not without danger. He states that greater skin reaction occurs over bony prominences and no case should be taken beyond a dry scaly desquamation stage. Since a large volume of the bone marrow is involved and the heart and circulating blood is exposed, leucopenia, chiefly affecting polymorphonuclear cells and later lymphocytes and still later red blood cells may develop. Constitutional symptoms of lassitude, nausea and vomiting may occur. In treating males the testicles should be shielded by lead. In the young females artificial menopause may occur and chromosome abnormalities, which in later generations cause developmental abnormalities, may be present. The effect of X-ray therapy on the disease is: Pain is decreased or abolished; paravertebral spasm is relaxed; stiffness is lessened and spinal motion and chest expansion is increased; the whole mental outlook changes; there is a gain of weight; and, the sedimentation rate is lowered.

A second course of treatment should not be considered in less than six months.

Radioactive thorium treatment has been used in spondylitis with reported comparable results (144).

C. Osteoarthritis or degenerative joint disease.

With reference to the treatment of osteoarthritis, the situation is not a very satisfactory one according to Fletcher (145). He very appropriately states that "rest" is the primary treatment of choice. He recommends adjustment of posture as of obvious importance, since joints put at a mechanical disadvantage tend to show degenerative changes after a varying length of time. Correction of mechanical defects are therefore essential. He further states that heat, preferably in the form of diathermy, is the best form of physiotherapy. In hip involvement at least one hour a day of diathermy should be given five days each week. Weakness and wasting of muscles are treated by non-weight bearing exercises. He further recommends injection of joints with various drugs or chemicals, especially 0.5 per cent procaine, but cautions as to the extreme care concerning sterility in technique. In some cases he has found manipulation with stretching of the capsule, under anesthesia, of value. He refers to vitallium cup arthroplasty as a popular operation and also to joint debridement as described by Magnuson in 1941.

By far the majority of articles dealing with treatment of osteoarthritis published in 1948 dealt with the injection treatment of this disease.

Waugh (146) stated that in rheumatoid arthritis the synovial fluids became relatively alkaline with a p H around 7.8 and in osteoarthritis the synovial fluid approached a p H of 8. To his cases he gave injections weekly or fortnightly using a stable solution of procaine lactic acid at a p H of 5.0, injecting 1 ml into interphalangeal joints, 2 to 4 ml in the wrist and shoulder joints, 5 to 10 ml in the knee and 10 to 15 ml in the hip. Before injections the joints were aspirated, and afterwards manipulations and frequent active exercises were carried out by the patient. His results in

osteoarthritis and the less active forms of rheumatoid arthritis were "most encouraging" in that greater mobility and relief of pain ensued. In patients with bilateral involvement, more marked improvement was seen in joints treated by injection plus physical therapy as compared to the contralateral joints treated by physical therapy alone.

Baker and Chayen (147) described the intra-articular injection treatment of osteoarthritis, and of 52 cases, 16 patients were "greatly improved" and only 13 showed no improvement. It was found that lactic acid solution, a p H adjusted procaine solution and normal saline all seemed to have about the same effect, namely an increased range of motion allowing for increased exercise and movement. They believed that the "lubricating effect" of the injected fluid was of importance and that fluids of higher osmotic pressure and viscosity might afford more benefit. Following the procaine effect from the injections, active non-weight bearing exercises are required; symptoms were relieved for about two weeks and then another injection was given.

Holmes (148) described improvement in osteoarthritis of his own hip attributed to treatment by Waugh. In 1938, after riding and hunting, he experienced a painful left hip and had to cease riding in January 1939. By 1945 he was unable to walk but for a short distance due to severe pain. Roentgenographic examinations revealed "severe osteoarthritis, left hip - too dense for detail". After the third of ten injections the pain was decidedly less and exercise movements were less painful. His treatment was begun in June 1947 and ended in December 1947, at which time he was able to stand for three to four hours.

Nicholson (149) demonstrated with radiopaque dye that only one out of twenty-five injections of procaine lactic acid was actually given within the joint space itself in three patients with osteoarthritis of the hip. However, two of the patients showed improvement which was attributed to the injections. He criticized Waugh's observations referable to the p H of synovial fluid on the basis that the p H of the fluid in vivo and in vitro may not be comparable due to rearrangement of gasses between the fluid and the environment and suggested that more accurate determinations are needed.

Graubard, Kovacs and Ritter (150) reported on the use of intravenous procaine injections in nine cases of osteoarthritis, four of rheumatoid arthritis, one of traumatic arthritis and one of Legg-Perthes disease (a total of fifteen cases). A total of 137 injections were given using four milligrams of procaine per kilo of body weight dissolved in isotonic saline solution to make 0.1 per cent solution (1-1000). The total dosage was administered over a twenty minute period and the injections repeated at weekly intervals, depending upon the general condition of the patient. Relief of pain, loss of muscle spasm and in some cases increased mobility were noticed within a few minutes. They caution against too rapid administration or the use of too concentrated solutions to prevent occurrence of toxic manifestations or convulsions, and found that injection of soluble barbiturates was effective in relieving the latter, and that the use of epinephrine, camphor and oxygen is indicated for respiratory or circulatory collapse. They further state that this treatment may be contraindicated in cardiac disease, particularly if digitalis is used. They rationalize this form of therapy upon the elimination of the reflex cycle initiated by the irritative process after procaine infusion resulting in the diminution of vascular spasm and improvement in

circulation which is followed by the relief of pain and increase in mobility. They further state that gold therapy is of little or no value in destructive arthritis of the hip, that the physiotherapist can offer much in the way of relief, but this is temporary and exacerbations have been induced, that surgically the results are not persistently good and that all cases cannot be considered for arthroplasty; that neurectomy of the obturator nerve has not produced encouraging results; that radicotomy of the third, fourth and fifth lumbar roots is of doubtful value; and, that although fifty to sixty per cent of the cases treated by intra-articular injections of lactic acid reportedly improve, that these figures have not been confirmed. They believe, therefore, that the intravenous administration of procaine obtains more persistent good results than the other methods employed and that it is an important adjunct, not a cure, in the management of destructive arthritis of the hip.

Borak (151) states that in osteoarthritis, particularly of the knees, hands and hips, something may happen to a degenerative joint of long standing and of relative freedom of symptoms and the joint becomes hot, swollen and painful. In this "inflammatory type" X-ray is better than in any other type and he states 100 r calculated at the joint and given at intervals of one to two days produces quick remarkable relief. A few larger doses are then given to prevent recurrences. In the "fibrositic type" (commonest type) involving the knees and fingers, periarticular fibrositis involves the joint capsule and muscle stiffness ensues, which does not yield to X-ray as readily. Larger doses, 150 to 200 r, calculated at the joints and given six to eight times at intervals of two to four days will be required. He states that in the "hyperplastic type" 1000 r given within two to three weeks, a single dose being not less than 200 r, should be given. He further states that in no stage is it ineffective.

In "discogenetic disease", exemplified by the so-called hypertrophic arthritis of the spine, true symptoms are due to encroachment on the foramina with pressure on nerves and thus nerve root symptoms. Mild edema in connective tissue in such a foramen may cause considerable symptoms. Borak states that X-ray is often helpful if the diagnosis is correct and the proper part treated, and 50 to 200 r calculated at the level of the intervertebral foramina given three or four times at intervals of from two to three days in an early stage. In the advanced stage he gives six to eight treatments and in the very advanced stages the single doses amount to 300 r.

D. Treatment of miscellaneous forms of rheumatic diseases.

Lipkin (152) states that procaine injections may be indicated in cases of: 1. Localized fibrositis. 2. Non-suppurative bursitis. 3. Brachial or sciatic neuralgia. 4. Traumatic disorders (sprains, fibrositis or arthritis). 5. Osteoarthritis. 6. Rheumatoid arthritis (inactive). 7. Specific infectious arthritis (inactive). 8. Coccygodynia after careful study has ruled out the presence of visceral disease. He lists the contraindications of: 1. Known sensitivity to procaine. 2. Extremely apprehensive or neurasthenic individuals. 3. Uncontrolled diabetes. 4. Sites of or near infected areas. He recommends preliminary sedation with 0.1 gm of sodium amytal one hour prior to injections and the dosage recommended is from 3 to 30 cc in a 1 per cent solution of procaine. In local fibrositis he injects 5 to 10 cc, in brachial plexus blocks 10 to 20 cc and in sciatic blocks 20

to 30 cc. The injections are given at daily to five day intervals. Of his 100 patients "38 recovered completely, 42 showed marked improvement, 6 failed to respond and in 5 the results were unknown". No supplemental therapy other than exercise within tolerance was given. He recommends this form of therapy as an important adjunct and not a "cure" in that it prevents atrophy by allowing increased motion by relaxing muscle spasm and relieving pain.

Mayer (153) described the use of a plaster bed and traction to a lower extremity with "infective arthritis of the hip joint", a method which maintains fairly simple and easy movement of the patient for therapy and nursing care.

Borak (151) states that in para-arthritis ("tendogenetic disease") exemplified by the "frozen shoulder" originating from calcific tendonitis even though considerable calcium may be present and if in the acute stage, the condition will respond favorably to X-ray therapy within a few weeks. Chronic cases, even though the calcium deposits may be small, may take a long time for improvement to occur. Asymptomatic calcium deposits will show no response to X-ray therapy. He states, therefore, that X-ray affects the underlying inflammatory process. In the non-calcified variety of peritendonitis, bursitis or peri-arthritis the principles of treatment are the same.

PHYSICAL THERAPY

The various modalities employed by physical medicine in the treatment of arthritis are discussed by Hansson (154). He emphasizes the importance of maintaining or reconstructing proper body mechanics and posture in the arthritic patient, and states that massage and exercise are indispensable in their management.

Walker (155) stresses the importance of gradually increasing exercises in the chronic ambulatory stage of rheumatoid arthritis. After the disease becomes quiescent, he sees a need for gentle manipulation under anesthesia. In the treatment of osteoarthritis a more vigorous regime of stretching and manipulation results in more striking results than in the rheumatoid patient.

Moor (156) reminds us that in the past rest for arthritic joints has been overemphasized and cites the need for a balance between rest and exercise of the joints. Heat, massage and vaso-dilating drugs by iontophoresis are valuable adjuncts.

Kistler (157) sees physical medicine as the one most potent single weapon in the treatment of arthritis. He recommends daily heat, massage, occupational therapy and exercise with emphasis on the latter. These exercises should be simple, practical and easy to perform.

A list of practical and easily performed exercises are discussed by Osborne (158).

Stengel (159) reports satisfactory results in 90 per cent of 400 rheumatoid patients treated with iontophoresis using magnesium sulfate, sodium salicylate, histamine and mecholyl. He believes that an elevation of the sedimentation rate occurring while a patient is receiving physiotherapy is a contraindication for that particular modality.

Brokaw (160) recommends the employment of occupational therapy as soon as the heat and swelling in the joints begin to subside and the sedimentation rate starts to drop toward normal. He cautions against substitution of muscles and stresses the importance of correct posture and maximum position of joints for function. He advocates many of the common household tasks as a means of exercise.

In a discussion on therapy, convalescent care and rehabilitation in rheumatic fever Kresky (161) recommends: 1. Bed rest and adequate drug therapy during the acute phase. 2. Slow, careful convalescent care with an attempt at occupational rehabilitation. 3. A cheerful, optimistic attitude during the acute attack and during convalescence in order to prevent the development of a "cardiac neurosis". 4. After recovery, a complete occupational re-evaluation and re-education in terms of his cardiac disability. 5. Immediate preventive measures at the onset of a cold, sore throat, an attack of tonsillitis or sinusitis. 6. Periodic check-ups to re-evaluate both the cardiac and the occupational status.

ORTHOPAEDIC TREATMENT

A review of the literature on arthritis reveals that the rheumatologist is working more and more in closer conjunction with the orthopaedist.

Law (162), (163), (164) emphasizes the importance of undertaking reconstructive surgery before joint destruction is complete and before serious atrophy of muscles and ligaments has developed. Orthopaedic measures are carried out simultaneously with other forms of treatment. Treatment is directed toward the relief of pain, arrest of disease, maintenance and restoration of function, and the prevention and correction of deformity. During the acute stage of rheumatoid arthritis rest and splinting are employed, and as the inflammation subsides physical therapy is increased. Milder deformities are corrected by wedging casts and manipulations under anesthesia. He discussed the indications for operative measures, such as: excision of the acromion process in rheumatoid arthritis of the shoulder joint; excision of the head of the radius and subtotal synovectomy in some cases of arthritis of the elbow; arthroplasty of the elbow; excision of the distal end of the ulna to improve radio-ulnar function; capsulotomy or capsulectomy with or without resection of the interphalangeal and metacarpophalangeal joints of the hands and feet; and, arthroplasty of the hip joint by the Smith-Peterson vitallium mold technique. He states that arthroplasty of the knee is not too satisfactory, but offers some promise. Arthroplasty of the temporomandibular joint may be helpful to relieve pain and improve motion. In ankylosing spondylitis spinal osteotomy has beneficial effects.

Similar principles of treatment are outlined by Young (165).

Bach (166) in his chapter on "Orthopaedic Intervention in Arthritis" discusses generally the indications for synovectomy, capsulotomy and arthroplasty in rheumatoid arthritis and for fusions and reconstruction operations on the hip and knee in osteoarthritis.

Batchelor (167) reports that excision of the femoral head and neck followed by osteotomy can be relied upon to give a painless stable joint with 75° to 90° range of motion in unilateral traumatic and degenerative osteoarthritis, ununited fracture of the femoral neck and fracture-dislocation

of the hip. In ankylosing spondylitis and rheumatoid arthritis, excision of both hips followed by osteotomy has restored to limited activity patients formerly bedridden. He recommends the procedure also in chronic suppurative arthritis.

Manipulative treatment and supportive Orthopaedic measures are discussed by McCauley (168) who stresses the importance and preference of active exercise over passive exercise in the movement of arthritic joints. Occasionally in selected cases he sees a need for careful manipulation under anesthesia which may be followed by excellent results. He also describes the optimum position for joints at rest and supportive measures to maintain these positions at rest as well as in the ambulatory stage in the treatment of arthritic joints.

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SECTION 6

POLIOMYELITIS

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A complete survey of poliomyelitis in all its aspects was conducted by representatives of 60 countries, in a week-long conference of the First International Poliomyelitis Conference, sponsored by the National Foundation, 12 July 1948, in New York City. The Conference is completely reported by Tenbrinck (1). Her material makes a source for the best current thought on this subject.

Green (2) reviews our present knowledge regarding poliomyelitis. Many new types of treatment have been introduced and a few have merit, but no treatment changes the progress of the acute stage greatly. Much publicity has been given the disease by an organization that is nation-wide in its scope. The information given the public is intended to be scientific, but this is not always the case. One feature of the epidemiology should be emphasized: The increased incidence of bulbar poliomyelitis in patients shortly after tonsillectomy. Tonsillectomy during an epidemic is undesirable.

Infantile paralysis is characterized by an acute illness that, in its first phase, may be non-specific but soon causes symptoms referable to the central nervous system. If one pictures a disease in which one muscle group may be paralyzed and the opposite group in painful spasm, it can be appreciated that deformity may result. The effect on the central nervous system is wide-spread, but most damage is done to the anterior horn cells. It should be emphasized that the spasm is not the most damaging effect of the disease, as proposed in the Kenny concept, but it is a symptom that, with sensitivity, tends to be deforming in the early stages. Curare and prostigmine have not been of particular benefit in the treatment of the disease. The treatment is carried on best by dividing the disease into three stages.

During the acute stage, the patient should not exert himself. Bulbar involvement is indicated by such signs as difficulty in swallowing, changes in the voice and irregularity of respiration. In the bulbar type, the head is kept dependent and manual aid to respiration is given, if necessary. In spinal respiratory type, the use of the respirator is indicated.

Convalescent stage: Physiotherapy is increased and hot packs to muscles in spasm are used. The parts are kept in good position with feet held at right angles. A muscle evaluation should be made after the temperature has been normal for 48 hours and this examination should be repeated at regular intervals. After the insensitive phase of the convalescent stage is reached, actual stretching of the contracted parts is sometimes necessary.

Chronic stage: Physiotherapy is continued with the hope of complete

rehabilitation of the patient. If surgery is necessary, it is continued as an adjunct.

Most of the clinical observations of poliomyelitis have been limited to that relatively rare form of the disease which results in residual paralysis. Even here no controlled observations have been published which enable one to say whether a great variety of symptoms are really typical of this disease. Current articles list diarrhea, sore throat, running nose and cough as symptoms, but offer no proof.

A group of 64 cases of subclinical poliomyelitis, proven by the finding of the virus in throat or stool culture; 33 cases of clinical poliomyelitis, manifested by paresis, paralysis, reflex changes, etc.; and 157 cases, classified as non-contact or control cases, in which stool and throat cultures were negative for the virus, were studied by Casey and Fishbein (3). The incidence of the various symptoms and signs in the 157 control children was compared with the incidence of various symptoms in the 64 children with subclinical poliomyelitis. Fever, headache, constipation and drowsiness occurred significantly more often among the children with subclinical poliomyelitis than among the control group. Noteworthy was the fact that sore throat, diarrhea, running nose and cough were not significantly related to the symptoms of subclinical poliomyelitis. The symptoms in the patients with clinical poliomyelitis were then compared with those in the control group. Again running nose, diarrhea and cough were not symptoms of clinical poliomyelitis, but sore throat and leg ache were. The symptoms of headache, vomiting, constipation, drowsiness and mild fever were of statistical significance as in the subclinical form. The difference was that headache, vomiting, constipation, drowsiness, fever and leg ache were more often encountered in the clinical than in the subclinical form. It is interesting sore throat had no relation to symptoms of the patients with the subclinical form of poliomyelitis but was often present in children who had stiff neck, stiff back, head drop and paralysis.

The whole diagnostic problem of poliomyelitis is presented by Caughey (4). He includes the incidence and mortality rates in New Zealand and the present concept of the disease. The author describes the following types of cases: The healthy carrier, the convalescent carrier, the abortive case, the pre-paralytic case, and the paralytic case. He discussed the diagnosis, the subjective and physical findings, the clinical pathology and the differential diagnosis in each stage.

As part of a symposium on poliomyelitis, Robertson (5) briefly discusses the symptomatology, existence of the healthy carrier state, and the therapeutic use of various drugs, as well as some inherent constitutional characteristics of the paralytic patients which tend to pre-dispose the individual to the disease. He cites the work of W. Lloyd Aycock, who found that 51% of the poliomyelitis victims gave a positive family history of the disease, whereas such a history was obtained on only 5% of the unaffected individuals. The author also discusses the observations of Draper in 1916, as well as his own, that the poliomyelitis patients have certain anthropometric characteristics, and a tendency toward obesity, eunuchoidism or hypogenitalism.

A clear and concise presentation of the known facts and current theories of all aspects of acute poliomyelitis (both spinal and bulbar) is outlined

by Miller (6).

Keiser (7) reviews a few of the facts known about poliomyelitis. It is pointed out that there are some 13 strains of the virus, that the virus is taken into the body through the GI tract and the treatment is symptomatic.

Russell (8) establishes two premises, based on a study of 54 patients with poliomyelitis, first, that poliomyelitis may be diagnosed on clinical findings before the appearance of paralysis, and second, that physical activity in the pre-paralytic stage increases the incidence of paralysis. He considers the so-called meningitic symptoms of most significance since they are almost universally present in the pre-paralytic stage. They suggest involvement of nerve roots rather than the meninges, and consist of pain in the head, neck, and in the dorsal, lumbar or sacral spine, in addition to the scapular region, thighs, or lower chest, singly or in combination. These pains vary from mild to severe. Fever may be absent. The meningitic symptoms may abate and the patient may even be subjectively improved just prior to onset of paralysis. A review of the patients' records indicates that those who indulged in physical activities during the pre-paralytic stage tended to show a greater incidence of subsequent paralysis, and also had a greater severity of paralysis. He concludes that complete physical rest in bed during the whole of the pre-paralytic stage helps protect the patient from severe paralysis as much as, or more, than any other single factor.

A report based on 100 cases of acute poliomyelitis admitted to St. Luke's Hospital, Kansas City, Missouri, during the summer and fall epidemic of 1946 is presented by Jones and Dickson (9). Prostigmine proved of little or no value in the treatment of acute poliomyelitis, and the side effects were objectionable. Curare had little or no beneficial effect on paralyzed muscles, but relieved pain, muscle spasm and discomfort, and was especially valuable in cases of laryngeal and intercostal paralysis.

Arvola (10) gives his observations of the follow-up examinations of 117 poliomyelitis patients with paresis, who were admitted to the City Hospital for Communicable Diseases in Helsinki from 1937 to 1942. His series, admittedly small, led to the following conclusions: Adults now contract the disease as often as children, but in children the disease is milder and the prognosis better. The mortality is higher in adults, lowest in the group under the age of seven, and higher among males than females. Within 8½ years, 17% of the paretic cases had completely recovered, over 40% were practically well, 60% had slight defects, and only 14% were seriously disabled. 87% of patients over 18 were capable of self-support. The milder the paresis originally, the greater was the tendency toward muscular recovery. In patients under 15, the greater the original paresis, the greater the tendency to limb shortening. Serious paresis always resulted in shortening, mild paresis never. Joint contracture and flaccid joints were the usual deformities in children, while scoliosis was frequent in adults. Continuous medical supervision gave the best results.

The results of a survey of the poliomyelitis admissions to 270 hospitals of England and Wales during the period 1 Jan. to 11 Oct. 1947 is given by Bradley and Gale (11). The survey includes a total of 4,717 cases, of which one-third were under 5 years, one-third between 5 and 15 years, and the balance

over 15 years. The mortality of the series was 7.6% (360 cases). It was greater in older patients. 3461 cases (73.3%) showed paralysis, of which 2,976 had involvement of the limbs or trunk, and 485 had involvement of the cranial nerves. 1097 patients had no paralysis, but were diagnosed on the changes in the cerebro-spinal fluid or on clinical grounds only. Of the 3138 non-fatal paralytic cases, 41.1% were mild, 38.5% were moderate and 20.4% were severe. Respirators were used in the treatment of 310 patients of which 93 are likely to require this mechanism permanently.

In an account of the epidemic of poliomyelitis in the Jamestown, N. Y. area, during 1947, Clark and Furlong (12) give their experience with 74 reported cases in the hope that it will be helpful to individuals dealing with a similar situation in their own localities. This is a very detailed report and comes to the following conclusions: 1. Exercise during the prodromal period makes the prognosis worse. 2. During an epidemic, persons with "grippe-like" symptoms should be put to bed. 3. Fatigue, over-exercise, trauma, infection and chilling are related to the onset of clinical cases. 4. Patients should not be up until tightness of the muscles has been relieved by rest or physical therapy. 5. There is no correlation between the protein in the spinal fluid and the severity of the disease. 6. Antispasmodic drugs have been disappointing in their effects. 7. The number of cases in the first few weeks is an index of the severity and duration of an epidemic.

Edwards (13) analysed 149 fatal cases of poliomyelitis. He gleaned the series from cases of poliomyelitis in military personnel in the United States. The average mortality rate for army cases from 1940-1945 was 17% as compared with a rate of 9% in the general population. This is ascribed to the difference in age groups. Of the 149 cases, 8 were negroes. One hundred twenty-two cases were bulbar spinal, 24 bulbar, and 3 encephalitic. 14 cases died of respiratory failure. Stiff neck was more frequently seen than stiff back. 122 cases developed paralysis of extremities. Paralysis of intercostals (69%) was more frequent than that of diaphragm (42%). Of the cranial nerves the 10th was involved most. Dysphagia was observed in 93 patients. In 87%, paralysis developed within 4 days after the onset of symptoms. 93 patients showed normal reflexes. As the bulbar cases showed ascending signs, the deep reflexes disappeared. Spinal fluid findings were often incomplete. It was clear in 82%, and with a cell count between 100-500 wbcs in 45%. Chemistry on the spinal fluids was within established limits. Sedimentation rates were elevated in 78%. In fatal cases, death occurred most commonly between the 3rd and 4th days. The treatment of the disease did not vary from established standards. Misdiagnosis included tetanus, hookworm, battle fatigue, sand fever and malaria.

McAlpine (14) makes observation of the 1947 poliomyelitis outbreak in England. Non-paralytic and paralytic cases are essentially the same as other series in the U. S. and England. He discusses in detail the diagnosis of polioencephalitis on the findings of nystagmus, photophobia and neck rigidity, during an epidemic in a patient who had been ill for a few days with headache and fever. He had several examples of a rare ocular disorder during the epidemic associated with emotional instability, tremor of the head and mild cerebellar seizures.

Leslie and Wheeler (15) studied 202 cases of poliomyelitis admitted

to the Childrens' Hospital in Columbus, Ohio, during 1947. This group of cases included adults, as well as children. They found their patients did not differ markedly from the usual picture described for poliomyelitis. They felt that several features deserve emphasis: 1. A greater proportion of older patients suffered severe forms of the disease than was expected. 2. A history of contact was obtained in a significant number of cases. 3. Spinal paralysis occurring in association with bulbar involvement tends to affect the muscles of the neck, shoulder girdle and chest. 4. One should not exclude the diagnosis if the cerebrospinal fluid contains less than 10 cells per cubic millimeter. 5. It is possible for significant new paralysis to develop after fever has subsided. 6. The respirator should be used early in cases of respiratory muscle weakness. 7. Tracheotomy should be used when it is clear an adequate airway cannot be maintained.

Kelleher (16) has written a complete discussion of acute poliomyelitis, which attempts to give the average practitioner an insight into the clinical picture of the disease. The remarkable increase in poliomyelitis in England during 1947 made the disease a problem for all doctors. The article is detailed in its consideration of the diagnosis of the various clinical types.

Horstmann (17) makes a very complete presentation of the problems of the epidemiology of poliomyelitis. She traces the history of the disease from the ancients to the modern epidemics. The age incidence changes with the duration of epidemics as illustrated by Japan and the U. S. Early the disease is definitely infantile with a high paralytic rate. In recent U. S. epidemics there have been ever increasing numbers of abortive and non-paralytic cases. It has been suggested that the virus is so widespread in poorly sanitized areas that infants are repeatedly exposed in life to subinfective doses and thereby acquire a lasting immunity.

The infection of the U. S. soldier in the Philippines and in similar places suggests the conclusion that the distribution of cases was related to the susceptibility or immunity of the host. Owing to the prevalence of the virus, the native population had acquired a substantial immunity. In addition to the above, it is quite possible that there are strain differences in various parts of the world and that the immunity may be highly strain-specific. The virus is eliminated with greater frequency and for a longer times in stools than in material from the oropharynx.

In animals (Chimpanzees) it has been shown that animals sacrificed during the carrier stage, the asymptomatic, may have severe, but scattered lesions throughout the central nervous system. These animals, though clinically well, excrete the virus in their stool.

The diphasic course of the disease occurs in about 50% of cases. The virus probably enters the body by way of the mouth and pharynx and passes through the upper and lower intestinal tract within 24-72 hours. It becomes implanted in certain sites, notably the pharynx and small intestinal wall, where it multiplies. It seems possible that any factor, physical or chemical, may alter the metabolism of the cells of the central nervous system to upset the host-virus equilibrium and thus precipitate paralytic disease in persons, who might have remained healthy carriers.

The facts indicate that fecal contamination of hands, food, etc., constitute the mechanism of spread rather than from the upper respiratory tract.

Evidence points that flies are an accidental reservoir of the virus and not the important link in the change of events leading to epidemics.

Strauss (18) traces the history of poliomyelitis in the U. S. and comments on the changing age incidence. 25-50% of cases are over 5 years, whereas initially it was almost exclusively a disease of children under 5. In Japan, where the first epidemics are being experienced, the latter still holds.

There is no evidence of any reservoir of poliomyelitis other than man. Water and milk have not been shown to spread poliomyelitis. Epidemics show a radial spread which is characteristic of person to person spread. It is difficult to show a connecting link because of the chain of as many as 100 abortive cases between two paralytic cases. The virus is rarely present in the nasal secretions or saliva. 10-40% of the cases show it in the throat, however. It is present in 75-80% of intimate contacts. The abundance and persistence of the virus in the stool suggests fecal rather than respiratory spread.

Practical measures of control are difficult to apply. Isolation and quarantine are necessary, but cannot control an epidemic. Ideally, the presence of the virus in the stool should determine quarantine but this is, of course, impossible.

The question of closing schools, playgrounds, theaters, and swimming pools always arises. The author feels it is reasonable to close playgrounds and swimming pools.

A plea for improved sanitation along railroads and canals (England) is made by Broadbent (19) to control poliomyelitis. He points out the high incidence of the disease along both these systems, which maintain only "primitive sanitation".

A report by Nissen (20) describes a poliomyelitis epidemic of 217 cases affecting the population of the Virgin Island, St. Helena. The epidemic began in Jamestown in November 1945 and, after some delay, spread to outlying districts. There was some evidence that the virus was introduced from South Africa. The incubation period of the first case was 31 days. The highest incidence occurred in the age group 5 to 19 years. Two-thirds of the cases were abortive, 77 cases were paralyzed, and 11 (14.3%) cases were fatal.

Ryle (21) presents a study of an outbreak of poliomyelitis in an English residential school of 411 pupils. Poliomyelitis occurred in two houses of 48 and 43 boys. There were no cases in the rest of the school. The author was struck by the high incidence of minor illnesses in the "polio" houses, which was 31% and 21%, respectively, as compared with an incidence of 6% in the remainder of the school. The minor illnesses were colds and intestinal upsets.

In a most comprehensive and complete discussion Aycock (22) gives observations of the behavior of poliomyelitis in warmer climates. He finds the spread of the virus is a function of ordinary unavoidable and probably

irreducible contact. Infection with the virus is preponderantly benign with paralysis occurring in only a small fraction of those exposed. In the tropics, widespread exposure, more frequently during the persistence of equally widespread maternal immunity, apparently results in a modified infection with resultant active immunity to be passed on to the offspring for repetition of the cycle. Thus, a high degree of commensalism has been reached. The mechanism through which a lower incidence of paralysis occurs in warmer climates seems to be the operation in nature of the principle of variolation rather than the principle of vaccination.

According to Dauer (23) the incidence of poliomyelitis in the United States during the year 1947 was less than for any year since 1942. It was 50% (15,000 cases) less than in 1946. Only four states reported higher rates in 1947 than in 1946. The greatest number of cases were in heavily populated areas (Ohio, New York, California, Illinois, and Michigan), but the highest rates per 100,000 were in Idaho (72.1), Delaware (39.2), Rhode Island (18.9), and Nebraska (15.4). The case rate for the country was 7.4 per 100,000 population. The largest area, where the disease was epidemic, included Southern Idaho, Eastern Oregon and Western Wyoming. In contrast to the U. S., the incidence of poliomyelitis increased in 1947 in the British Isles and Western Europe.

An analysis of 104 patients admitted to a service for the treatment of early acute poliomyelitis is made by McAlpine et al (24). In 54 cases, of which 24 were non-paralytic, a diagnosis of acute poliomyelitis was confirmed. No deaths occurred. In nearly one-third of the proved cases, contact histories suggested the probability of an abortive attack of the disease in other members of the family or in friends.

Current facts and theories and the history of poliomyelitis are given in detail by Meenan (25). He concludes there is no single portal of entry, but the area most often involved would seem unquestionably to be the pharynx. The nerves most frequently involved are the trigeminal afferent system from the nose, mouth and pharynx and visceral afferent system of the ninth and tenth cranial nerves, serving in addition to the above the esophagus and bronchi, stomach and intestines. The seventh cranial and the sympathetic systems are also occasionally involved.

In a summary and evaluation of present-day concepts of poliomyelitis, Freidewald (26) stresses the pathogenesis and diagnosis. He states the virus of poliomyelitis is found in the alimentary tract of a large proportion of the population during epidemic periods. In only a small percentage, however, does it invade the central nervous system. The diagnosis, which may be difficult in the abortive and non-paralytic types, is almost entirely dependent on the clinical manifestation and the spinal fluid findings.

Francis, Brown and Penner (27) made a search for extra human sources of the poliomyelitis virus. The best evidence of the transmission of the virus supports a person to person transfer. This opinion has developed from evidence based on processes of elimination rather than by scientifically proven experiments. Their attempts to isolate the virus from various extrahuman sources in epidemic areas have been made by inoculation of monkeys and cotton rats and mice. Thirty-three wild mice, 112 wild rats, 3 muskrats, 4 cats, 1 horse, many chickens, cows and hogs, and 43 pools of

insects, representing 15,300 individual specimens were tested. In addition, 24 samples of sewage, 2 of sludge, 1 of soil and 3 of milk were examined. Of 38 pools of flies, one collection of 23 sarcophaga spp. from rural Tennessee (1945) was shown to contain poliomyelitis virus. In all other attempts to isolate the virus, the results were negative. Virus from feces of a patient with poliomyelitis was actually taken up by flies and recovered by inoculation of rhesus monkeys.

Studies by Rosenow (28) indicate that specific streptococci, isolated from patients, are able to produce flaccid paralysis and degeneration of anterior horn cells in mice. He further describes presence of pleomorphic diplococci in lesions of the spinal cord. Air samples taken in epidemic zones showed the presence of specific streptococcal precipitinogen and streptococcus able to reproduce symptoms in mice. Lower titre of antibody in the serum of convalescent paralytics than in non-paralytics suggests that perhaps paralysis occurs as a function of insufficient antibody formation. The study indicates that a specific type alpha streptococcus is, in some way, related to etiology in epidemic poliomyelitis.

The theme of the article by Scobey (29) is that the implication of a virus as the etiological factor in poliomyelitis is not beyond question. In evidence: both brain and spinal cord material from poliomyelitis patients and similar material from normal animals can produce paralysis when injected into experimental animals. The author gives further evidence to support his hypothesis that human poliomyelitis and related diseases result from poisoning by cyanide contained in food and water, and that the so-called virus of poliomyelitis is very probably a leukomain or an enzyme resulting from accelerated autolysis from such poisoning. Reference is made to the author's previous work in which he implicated the hydrocyanic acid, found in the free state or as cyanophore or mustard oil glucosides in vegetables, fruits and water, as the etiological factor in poliomyelitis. Also, it is pointed out that Collins and Collins and Marland, 40 years ago demonstrated that poliomyelitis can be produced both in man and in experimental animals by cyanide.

A preliminary report is made by Lepine (30) of a test utilizing an interference phenomenon resulting in the protection of mice inoculated with material suspected of containing the virus of poliomyelitis against a subsequent inoculation with the Lansing strain of virus. Five mice, 4-6 weeks of age, were injected intracerebrally with extracts of the suspected material. The virus is extracted in the usual manner (P. Lepine, C. R. Soc. Biol., Paris, 1949, 131, 573). Two days later, these five mice, in addition to five mice used as controls, are given an intracerebral injection with active Lansing mouse-adapted virus, with each mouse receiving about 50 LD₅₀. The results drawn at the end of 10-11 days, showed 4 of the 5 controls dead or paralyzed and 3 of the 5 mice which were inoculated with suspected material were significantly protected. The materials used consisted of (a) cord material from monkeys inoculated with one standard laboratory strain and (b) fecal material collected from patients during the summer of 1946 and preserved in the frozen stage since that time. Extracts of normal human feces and cord material showed no protective action.

Helwig (31) describes the poliomyelitis virus from a physical and chemical point of view, and gives information as to its reaction to various

physical and chemical conditions. He outlines the culture methods, including the newer techniques employing human nervous tissue, chick embryo brains, etc.

Methods of determining strain variability by immunological, neutralization, reinoculation, and cross immunity studies, are discussed. Natural, active and passive immunity problems are considered, plus the difficulties and failures to produce effective artificial immunity.

Experiments reported by Loring et al (32) show that complement-fixing antibodies can be demonstrated in the blood of rats immunized with formalized Lansing virus, in convalescent monkey serum, and in some convalescent human sera when concentrated Lansing virus from cotton rats is used as antigen.

The experiments with the convalescent monkey and human sera provide definite proof that positive complement fixation can be demonstrated when concentrated Lansing virus prepared as described is used as the antigen. These latter results further support the importance of the Lansing virus or an antigenically related strain as the one responsible for the human disease.

The results of this study by Wenner and Tanner (33) indicate neutralizing antibodies do appear following an attack of poliomyelitis. They may be present early in the clinical course of poliomyelitis, and they may not increase to an appreciable extent in the months following. On the other hand, the antibody titre may show a marked rise. The increase varies with the individual and probably with the severity of the disease. The neutralizing antibody in some patients does not reach a high level, but in some cases, there is considerable increase. Also, it seems clear there is no appreciable drop in titre over the first year after illness. Apparently there is greater stimulation in paralytic than in abortive poliomyelitis. It appears that strains of poliomyelitis virus differ somewhat in antigenic mosaic, and this might explain differences in anti-body response. Individuals may have several abortive attacks of poliomyelitis, stimulating antibody production in varying degree. These antibodies, apparently, never reach high levels.

McCarter (34) reported the extent of the inflammatory lesions of 22 cases of fatal acute poliomyelitis and showed the constant involvement of the central portions of the medulla, pons and midbrain with more or less involvement of the basal ganglia, thalamus and hypothalamies. The report showed no fatal cases to have occurred without some brain stem involvement, particularly the reticular formation of the medulla and contiguous structures and that these lesions are among the earliest, if not the earliest, in the neuraxis. A variety of neural structures in the brain stem are involved which include the nuclei of motor and sensory nerves of both somatic and visceral function, and less well defined centers of vital function such as respiratory, cardiac, vasomotor and muscle tone inhibitory and facilitatory. The nerves so involved include the hypoglossal, abducens, trochlear, oculomotor, motor nuclei of the fifth and seventh and the nucleus ambiguus and thus give the clinical manifestations of "bulbar poliomyelitis". Also included are the great variety of symptoms which may stem from involvement of the general visceral afferent nuclei - dorsal motor nucleus of the vagus, nucleus salivatorius and occasionally the Edinger-Westphal nucleus. The

respiratory center is within the area of severe involvement of the brain stem. In spite of its large margin of safety, the extent of irreversible and reversible lesions indicates that respiratory failure may be due to other causes than paralysis of the respiratory musculature. The problem of maintaining life in the acute cases is related to the interference with the poorly defined cardiac and vasomotor centers. The explanation of the disturbances of muscle tonus based on the spinal lesions has never been satisfactory but it can be better understood in view of the lesions in the reticular formation of the brain stem.

Guyton (35) in his article "Relation of Symptoms to the Pathological Physiology in Poliomyelitis", emphasizes the fact that the virus of this disease attacks not only the anterior horn cells of the spinal cord but also the brain stem, the motor area of the cerebral cortex, and the sympathetic ganglia, as well as other areas of the spinal cord. Once the disease enters the central nervous system it spreads rapidly to all areas, giving symptoms related to the sites attacked. Encephalitis, meningitis, increased sympathetic central nervous system activity, urinary retention, and pain are common sequelae. Thus the lesions located in these widespread portions of the central nervous system cause a multitude of symptoms other than simply paralysis. Meningitic symptoms often herald the onset of the disease. Low back ache with occasional rigidity and neck pain is a common complaint. A spinal tap done during this period usually shows a moderate increase in white blood cells and protein. The spinal fluid pressure is usually slightly elevated. These meningitic symptoms are probably caused by irritation from the toxic products exuding through the pia mater from the areas of parenchymatous inflammation. The virus of this disease can rarely be found in the cerebro-spinal fluid. The symptoms usually last two to three weeks. Encephalitis may be quite severe and its time of onset varies with the site of the virus invasion. The encephalitic symptoms are due to the many midline lesions of the mesencephalon which often occur. There usually are no residual symptoms resulting from the encephalitis of poliomyelitis. Urinary retention is often the first symptom noticed in this disease and may precede paralysis for as long as two to three days. It is probably due to the involvement of secondary centers controlling bladder function which are located in the tegmentum of the pons and the reticular substance of the medulla. Retention usually lasts for only a few weeks because this portion of the brain has great reparative powers.

Symptoms arising from hyperactivity of the sympathetic nervous system may be both inhibitory and excitatory. The centers are located throughout the reticular substance of the medulla as well as other areas of the brain stem. The inhibitory centers are depressed to a greater extent leaving the patient with a hyperexcitable sympathetic system. As a result a rise in blood pressure and a fast pulse are common findings. The skin temperature is usually low particularly over the paralyzed portions of the body due to sympathetic vasoconstriction. Sweating is also a common complaint. Gastrointestinal symptoms are often among the most severe results of acute poliomyelitis. The salivary secretion is scanty and viscid. Anorexia and constipation are also common. In some patients vomiting is a prominent feature. Severe muscular pain and muscular tenderness are invariable results of acute poliomyelitis. The cause of this pain and tenderness is as yet undetermined

but it is possible if not probable that it is due to the hyperactivity of the sympathetic nervous system. The pronounced vasoconstriction might produce severe muscle ischemia such as that seen in Buerger's and Raynaud's diseases. Substantiating this contention is the fact that vasodilators ameliorate the pain. Heat, prostigmine, curare, and paravertebral anesthetization all produce beneficial effects. It is probable that the tendency to muscle contracture is related to the ischemia. The rapid fatigue of recovered muscles however appears to be a permanent symptom and is probably due to recovery by a process of axonal branching, thus overloading individual nerves.

Bodian (36) describes the course of poliomyelitis in the spinal cords of rhesus monkeys killed at intervals from the paralytic stage to the chronic stage. Included in the description are the cytopathological changes in motor nerve cells and more particularly in Nissl substance. Mitochondria and neurofibrils were found to be morphologically intact except in necrotic cells. It was found that axons degenerated between three and four days after cell destruction. Progressive stages of cell infection, destruction, and recovery are described. Paralytic animals show over 90% of all motoneurons are infected during the first few days, as is indicated by cytopathological changes in the cell. Changes first appear in the Nissl substance and progress in orderly fashion until there is serious involvement of nuclear structure. Studies made during acute and recovery periods indicate that large proportions of motoneurons injured to the extent of severe loss of Nissl substance recover their normal appearance. The relation between damage and recovery of the motor nerve cell population to motor paralysis and recovery is considered.

Knapp (37) calls attention to the possibility of involvement of internuncial cells in poliomyelitis. The function of these cells is not well known, except that they are concerned with the transmission of impulses from cell to cell within the central nervous system and are directly concerned with the correlation of motion. An explanation of the function of internuncial cells is as follows: The upper and lower motor neurons are connected by internuncial cells in parallel, and destruction of part of this bridge might result in muscle spasm in muscle which exhibits voluntary motor power. Also, it has been demonstrated that cats may have two neuron proprioceptive reflex arcs. If such a condition exists in man, it is possible all internuncial neurons could be destroyed and the muscle would still retain the source of impulse for production of spasm. Coordinated muscular movement is controlled by the central nervous system, and the motor pattern is produced by the interaction of correlated neurons. Because there is never less than a three neuron chain between the cerebrum and the muscle, there is at least one internuncial cell involved in every motion. Thus, motor pattern is produced by the interaction of correlated neurons. If anything happens to disturb any part of the pathway, the coordinated mechanism is upset. In poliomyelitis, such disturbances are evidenced by the spilling over of motor impulses into other muscles, which can be explained by the internuncial hypothesis. Recovery of affected muscles is explained as a training of new pathways through intact internuncial cells in cases of incomplete destruction.

Fox and Madden (38) made a study of the sedimentation rate in acute poliomyelitis, using the Westergren method. Sedimentation rate determinations were carried out in a temperature controlled laboratory. Ranges of from 0 to

15 mm for males and 0 to 20 mm for females in the first hour were considered normal. In a series of 136 cases, only 22 (16.2%) showed an increase in sedimentation rate. Of these, 16 were found to have concurrent infection accounting for the elevation. Thus, only 6 cases, or less than 5 per cent of the total, had an unexplained elevation of the sedimentation rate. The authors draw the conclusion that the sedimentation rate in uncomplicated poliomyelitis is quite constantly within the normal range, and that any elevation in poliomyelitis is highly suspicious of an improper diagnosis and the presence of a secondary infection. Also, this work suggests that there is no correlation between the white blood count, the spinal fluid cell count, and the sedimentation rate.

Sedimentation rates (modification of Westergren technique) were done by Hartman and Weinstein (39) on the following subjects: (a) Sixty-five patients (21 adults and 44 children) with poliomyelitis; (b) Forty-six patients with abnormal spinal fluids (22 suppurative meningitides, 19 viral and post-infectious encephalitides, 5 meningitides due to other causes); (c) Twenty-six patients (controls) who were thought to have clinical evidence of meningeal irritation or central nervous system disease, but who were found to have normal spinal fluids. Sedimentation rates were performed on patients with poliomyelitis at weekly intervals. The determination on patients with other types of central nervous system infections and on those patients suspected of having neurologic disease were performed usually only on admission since the purpose of the determination was to evaluate its early diagnostic significance. The conclusions drawn from this work are as follows: (1) Reliance on the sedimentation rate can be misleading in the differentiation of some cases of rheumatic fever and poliomyelitis. (2) In uncomplicated poliomyelitis and other viral infections of the central nervous system, the erythrocyte sedimentation rate is elevated in about 50% of the cases at the beginning of the disease. (3) The sedimentation rate is unreliable in differentiating poliomyelitis from other infections of the central nervous system which simulate it. (4) No correlation could be established between the clinical type of poliomyelitis, the severity of the disease or the degree of abnormality of the spinal fluid, and the elevation of the sedimentation rate. (5) The differentiation of viral and bacterial neurologic infections cannot be made on the basis of the sedimentation rate value. (6) The erythrocyte sedimentation rate should never be used as a substitute for a diagnostic lumbar puncture.

Pollack (40) has written an article on the neurological signs of early poliomyelitis. The most important prodromal symptoms are lassitude, drowsiness, irritability and general tenderness of the whole body. Before paralysis occurs there may be twitching of single muscles or whole muscle groups. Pain is a constant symptom and involves one or more muscle groups. The pain is usually associated with hyperesthesia. The author contends that muscle spasm has been greatly over-emphasized in this disease. Eleven neurologists examined 32 muscle groups of every case of acute poliomyelitis admitted to the Chicago Municipal Contagious Hospital, at frequent intervals each day over a 30 day period. Spasm was interpreted as a sustained, reversible tetanic contraction. They found no instance of muscle spasm. Tenderness was present in less than 25% of the cases. "Stretch pain" occurred in a few cases, particularly when paralysis was well established. Paralysis, contrary to the usual concept, does not appear suddenly and rapidly, but takes 3 - 5 days

to reach its peak and is preceded by weakness. The latter fluctuates from hour to hour.

Abt (41) presents an article which stresses the diagnosis of acute poliomyelitis and includes some notes on the history, incidence, epidemiology, and prevention of the disease. He quotes a recent article (Hayne, A. L., Illinois M. J. 92: 164, 1948), which enumerates the principal symptoms in 224 cases as follows:

Fever	218	Vomiting	95
Stiffness neck	172	Nausea	68
Headache	150	Sore throat	54
Stiffness back	130	Listlessness	46
Anorexia	101	Urinary retention	34

Kehoe (42) states that poliomyelitis has replaced lues as the great imitator. In his classification of the disease he includes (1) healthy carrier (2) abortive type, (3) and (4) acute poliomyelitis with and without paralysis, (5) bulbar type and (6) the encephalitic type. He calls attention to the fact that the abortive type is frequently called "flu". He concludes that there is no single pathognomonic element of history, symptoms, physical examinations or laboratory data that will give a positive diagnosis.

Because of the bizarre symptoms presented by many cases of poliomyelitis, the problem of diagnosis is often considerable, according to Toland (43). Early symptoms of the disease may be: rhinitis, abdominal distress, nausea, vomiting and headache. The latter is probably the most reliable early sign, occurring in 57% of cases studied by Pohl. Other suggestive symptoms are fever, stiff neck and back, painful extremities, and sore throat. Following initial symptoms, the disease may abate for 24 hours to 3 weeks, followed by paralysis or weakness of an extremity, often with pain and spasm of various muscle groups. Physical signs include absence or diminished reflexes in an extremity, muscle spasm, and usually no disturbance of sensoria. Bulbar poliomyelitis may be characterized by somnolence, respiratory difficulty, nasal phonation and facial weakness.

Diseases most commonly misdiagnosed as poliomyelitis are as follows:

(1) Encephalitides (many types). A history of recent diseases, such as measles, is important. These patients are usually more lethargic. This sign lasts longer than in poliomyelitis. They are weak with a definite early paralysis. Convulsions are more frequent.

(2) Acute lymphocytic choriomeningitis. There may be central nervous system symptoms and transient sensory changes, which are not found in poliomyelitis. Course lasts only 7-14 days. Spinal fluid shows 2000 lymphocytes and the virus may be demonstrated, whereas, in poliomyelitis, count usually runs around 350 leukocytes, polymorphonuclear early and mononuclear late.

(3) Tuberculous meningitis: This disease develops slower and produces a deep stupor, projectile vomiting and paralysis of extrinsic muscles of the eye. Spinal fluid may show tubercle bacilli and the chlorides are below 500 mg., whereas they are normal in poliomyelitis. Sugar is also lowered.

(4) Acute rheumatic fever: The reason for misdiagnosis is most often due to poor history and physical examination. Here the patient may be merely unwilling to move an extremity, whereas in poliomyelitis the patient is unable to do so. The sedimentation rate is elevated.

(5) Meningismus: Usually concurrent with some acute infection, presenting stiff neck and back. They are often relieved of symptoms following partial spinal drainage. This is not so in poliomyelitis.

(6) Purulent meningitis: Has hyperactive reflexes, whereas poliomyelitis shows hypoactive reflexes. The spinal fluid is cloudy, shows increased pressure, grows meningococci on culture and contains elevated protein and cellular content.

(7) Syphilitic meningitis: History and serology are important: Patients may have optic neuritis, convulsions, nausea and extrinsic ocular paralyses.

(8) Acute avitaminosis: Patients may not wish to move their legs because of pain and there may be a protective muscular spasm. Reflexes and muscle power are normal. The x-ray findings are often diagnostic.

(9) Intracranial lesions: Spinal tap, Queckenstadt test and x-ray may aid in the diagnosis. Hemologic examination may reveal definite focal lesion.

Other diseases less commonly mistaken for poliomyelitis have been: diphtheritic and arsenical neuritis, Guillain-Barré's syndrome, hysteria and trichinosis.

Woltman's (44) discussion of the differential diagnosis of poliomyelitis is very complete. He has drawn up a table of diseases to be considered in the pre-paralytic period. It includes choriomeningitis, encephalitis, lympho-granuloma venereum, acute purulent meningitis, tuberculosis, torula, typhus, etc., trichinosis and the common infectious disease of children. His differential diagnosis in the paralytic stage lists epidemic parotitis, periarteritis nodosa, Guillain-Barré syndrome, diphtheritic polyneuritis, acute porphyric neuritis, Landry's paralysis, botulism, tick paralysis, brain tumor, and hysteria. The urgency of poliomyelitis removes its differential diagnosis from the realm of an academic exercise. Its diagnosis must be considered, formulated and delivered at the bedside.

Fox et al (45) report a case of recurrent poliomyelitis with the first attack in August 1945 and the second in August 1946. Initial involvement was the musculature of neck, back, and calf, with no residual. The second episode involved chiefly neck, back, hamstrings, and bulbar signs, exclusive of respiratory mechanism. Again there was no residual. A review of the literature revealed 36 cases of recurrent poliomyelitis. These are presented in some detail. The period of time between the first and second episodes varied from one year to 29 years. The importance of understanding the difference in these cases of recurrent attacks and relapses and recrudescences of the same episode is stressed. Previous investigations had set forth the argument that there must be at least two years between the first and second episodes. The present authors feel this length of time is excessive and that, as in the case presented, the time lapse may be shorter. It is stated that

there is some immunity to the disease and this plays a role in the interval between first and second episodes. The belief that the second episode is caused by a different strain of the virus is set forth.

Horn and Weidenthal (46) report a case of poliomyelitis in a 3 weeks old infant. They state that ordinarily the disease is rare in infants under 6 months of age due to the supposed passive immunity they possess. Their case became irritable on the 17th day of life, developed fever, refused to swallow and became drowsy. There was no response to penicillin and oxygen and death occurred four days later. The autopsy findings indicated meningo-polioencephalitis. This report mentions four other cases under 6 months of age in the English literature.

Murray (47) asks for a review of terminology to assure uniform reporting of cases of poliomyelitis. His proposed classification includes (1) non-paralytic poliomyelitis, clinical and sub-clinical, (2) paralytic poliomyelitis including (a) spinal, (b) bulbar, and (c) bulbar-spinal, and (3) polioencephalitis.

A clinical report by Kobayashi and Kehoe (48) deals with the cases of poliomyelitis studied in the Iowa University Hospital from 1927 through 1937. After screening, 378 cases were finally studied. All of the 378 cases were in the white race. Age distribution was from 0 to 15.9 plus. The mean age was 8.3 years. Highest incidence occurred between 4 and 5.9 years. The peak incidence was in the month of August. Approximately 85% had no known contact with a case of poliomyelitis. 28% were the abortive type and 54% were purely the spinal type. The symptoms most commonly encountered were presented and were those classically associated with the disease. The physical findings were those usually noted. An interesting finding was the WBC ranged from 2000 to 27,000, with 75% less than 11,500. The mean leukocyte count in the cerebro-spinal fluid was 98. 80% were round cells. The mean value for spinal fluid protein was 49. It was significantly higher in the bulbar forms of the disease. Treatment was the classic type, consisting of splinting, packs, and sedation. A few were given curare. The groups treated with Kenny packs were compared to those treated with other methods. The percentages of recovery closely approximated each other for both methods. The mortality rate was 5.6% (21 cases).

Hullinghorst and Gifford (49) considered 170 cases of poliomyelitis in pregnant women. They found the susceptibility to poliomyelitis was not affected by age, number of previous pregnancies or the stage of the pregnancy. The bulbar type, which occurred in 23% of the group, did not increase the tendency to abortion, premature birth or precipitate delivery. The maternal mortality was 19% and the fetal mortality 26%. A third of the latter were intra-uterine. Caesarian section is proposed when the death of the mother is imminent. While the disease may be transmitted to the newborn, there is no definite clinical, histological or virological evidence of transmission in utero.

TREATMENT

Gurewitsch, Hallock and Dugan (50) discuss the treatment of poliomyelitis in the acute and convalescent states from the physical therapy and the

orthopedic aspect. Their aims are first to alleviate muscle pain, muscle shortening and limited flexibility, second, to develop optimal function of the weakened muscles, third, to rehabilitate the patient and make him as useful and independent as possible in the face of his handicap and fourth, to prevent the development of deformities in all stages of the disease. From the physical therapy standpoint, the method of choice since 1943 has been daily baths at a temperature of 104° Fahrenheit for 15 or 20 minutes repeated three to five times daily, depending on the severity of the symptoms. Passive exercises to all joints are started from admission. The first aim of muscle re-education in poliomyelitis is the restoration of exact control of individual muscles. Muscle training is repeated several times a day. A daily performance of a muscle is the only guide to the optimal amount of effort to which it should be subjected. If there is no return of power in four to six months, hope is given up. If muscles improve, exercises may be continued up to two years. Walking is encouraged by first placing patients on their feet in warm water up to the neck, which stimulates a multitude of postural reflexes without fatiguing muscles by weight-bearing, and then gradually reducing the level of the water. An attempt is then made to re-train muscles by functional occupational therapy. Psychological aspects were previously neglected, so great attention is given to recovery, rehabilitation, vocational training, and, in the adult, job re-training. Deformities are prevented by alleviating muscle pain and by preventing joints remaining for any length of time in a faulty position, and by opposing with mechanical means a deforming pull of imbalanced muscle. Proper position in bed is most important. Surgery is little needed since deformity can generally be controlled by treatment and with appropriate use of splints and braces. However, if deformity develops and does not yield to conservative measures, surgical correction is necessary. The above studies are based on the study of 552 paralytic patients, who were treated from 1942 through 1946 at the New York State Hospital, West Haverstraw, New York.

Cole (51) in discussing the present day treatment of acute poliomyelitis, feels the basic principle of treatment is the prevention of permanent and irremedial deformities. Under his regime, muscle spasm and shortening are treated by Kenny hot packs. He found prostigmine, curare, and sympathetic blocks to be unsatisfactory. Passive motion and stretching are begun as soon as pain ceases until a full range of motion of the joint is reached. This is followed by active muscle training and coordination. Loss of the proprioceptive reflexes is prevented by early standing and walking.

Lewin (52) stresses the institution of therapy during the acute stage of poliomyelitis as soon as the diagnosis is made. Of primary importance is rest which should be complete and absolute with the involved muscles in a position of neutral pull. It should be continued until the acute stage is over. External heat is used in the form of packs and continued until symptomatic relief from pain and spasm is obtained. Gentle passive exercises are subsequently given. After the acute stage, the importance of physical therapy and muscle training to prevent and correct contractures is discussed. The use of braces hastens the return of function or gives stability to atrophied parts. Surgical procedures are offered as means of overcoming deformities and contractures. The article includes a long list of directives which the author designates as "the Postulates of Polio" or "Poliograms".

Bennett (53) outlines the treatment of poliomyelitis and recommends the following steps:

- (1) Early and accurate diagnosis.
- (2) Preparation of the patient for resumption of activity.
- (3) Coordinate and strengthen the existing neuromuscular units.
- (4) Increase the functional capacity of the patient.
- (5) Orthopedic surgery, if indicated.

The results of treatment will be determined by the extent of central nervous system damage; and the caliber of medical care available; the general condition of the patient during the first three months; and the intelligence and responsibility of the patient and his parents.

An excellent summary of present day therapy of poliomyelitis may be found in an article by Blattner (54).

A regime for the treatment of acute poliomyelitis by Seddon (55) is quite standard in most respects. He gives no treatment to muscles that have remained paralyzed for 4 months. In addition he lists arguments for both early ambulation and prolonged rest in recumbency but gives no clear cut advantage to either.

An article by Wilson (56) outlines the treatment of the severe complications of bulbar poliomyelitis. Pharyngeal paralysis is treated with drainage, aspiration and lastly, tracheotomy. Laryngeal paralysis is treated with tracheotomy. When the respiratory centers are effected, treatment is of little avail. However, it is important to differentiate the former two from respiratory paralysis, since the pharyngeal and laryngeal paralysis may be aided. In summary, the treatment in severe bulbar poliomyelitis is palliative.

A tracheotomy inhalator is described by Elam (57) for administering humidified oxygen, with the optional use of positive pressure and of modifications in respirator collar and headpiece to accommodate a tracheotomy patient. The author distinguishes between (a) ventilatory deficiency with paralysis of the respiratory muscles, depression of respiratory center and obstruction of the upper airway and (b) alveolar deficiency with pulmonary edema, atelectasis and pneumonia. He recommends the respirator for (a) and oxygen for (b). An oximeter is used to follow the progress and to determine the need for a respirator and/or oxygen therapy.

Graves (58) discusses the problems of caring for patients with acute poliomyelitis in the respirator. He shows the physical therapist is of great value in helping the Doctor by (1) muscle studies which help determine the extent of the infection, (2) treatment of muscles effected with packs, (3) re-education of muscles, even though the patient remains in the respirator, and (4) improvement of the patient's mental attitude by occupational therapy as well as physical therapy. It is stated that 70% of the patients will require help while in the respirator in the acute stages of the disease.

Ransohoff (59) holds that muscle spasm is responsible for most impaired function including dysphagia, respiratory embarrassment and deformities in poliomyelitis and that by the use of curare such spasms are relieved. The

dosage of curare was 0.9 units per kg of body weight given every eight hours the first 24 hours, and then increased to 1.5 units per kg. given every eight hours intramuscularly. Administration of the drug was continued until spasm was relieved. The purpose of the above therapy is to **allow** stretching exercises and early ambulation, and thus reduce the incidence of contractures. Five bulbar cases responded well to the above treatment. He further points out that many of the "good results" were attributed to the determination of the physiotherapist rather than to curare. The consensus was that more work and clinical study is necessary before the practice of early ambulation following the use of curare can be received as an approved method in the early treatment of acute poliomyelitis.

In a report of 19 cases of acute poliomyelitis treated with "Intocostin", Rosenberg and Fischer (60) make the following conclusions: (1) Curare in doses of 0.9 units per Kilogram of body weight was of little value. (2) There was a very narrow margin of safety between the effective therapeutic dose and one which paralyzed the muscles of respiration or resulted in other toxic symptoms. (3) The addition of curare for periods of 3 to 10 days did not produce any more favorable results than those which had been obtained in previous years with hot packs and other forms of physical therapy.

In a preliminary report (79 cases) on the use of procaine HCl, Priscol HCl and diethylaminoethanol in the treatment of pain and spasm in the acute stage of poliomyelitis, Smith, Graubard et al (61) found the patients obtained complete relief within 24 hours with no deleterious side reactions. Occasional nausea and vomiting were present in the febrile stage. The rationale of the use of the drugs is an interruption of the sympathetic reflex arc which supposedly perpetuates the pain and spasm during the acute phase. The dosage schedule was: (1) Procaine HCl, 40 mg. per Kg given intravenously as a 0.1% solution in isotonic saline; (2) Priscol HCl, intramuscularly and by mouth, given as follows: (a) Adults: 50 mg intramuscularly every 4 hours for 48 hours and subsequently the same dose orally. (b) Children, over 5 years: 25 mg as above. (c) Children under 5 years: 10 mg as the elixir, with increases every 4 hours of 10 mg until flushing ensued. (3) Diethylaminoethanol HCl, 1-2 gm daily by mouth in 4 divided doses.

MacNamara (62) discusses the poliomyelitis problem in Australia, stressing the apathy of research workers of that country. He further outlines the history of serum therapy in the disease and questions the advisability of having given up this type of treatment. He feels many unsatisfactory results occurred because type "H" polio cases were treated with type "A" serum and vice versa.

A series of twenty patients with acute poliomyelitis were treated by Rappaport (63) with thermal antibody, a substance prepared by autoclaving and oxidizing NaCl suspensions of streptococci isolated from patients with acute poliomyelitis. All twenty patients showed improvement within one to five days, especially in regard to swallowing and return of muscle function. The author felt the antibody had curative effects and returned patients to normal activity in a short period of time. A new compound "phenosulfazole" has been utilized experimentally in the treatment of poliomyelitis in mice. The results indicated that the mice could be cured if treated in the early stages, that a single dose prevented infection, and that surviving mice were immune thereafter. The drug acts on tissue cells, rather than on the virus.

McCarroll (64) has outlined the treatment of poliomyelitis in the recovery and residual stages. The first marks the end of the destructive process and begins when the temperature has finally subsided. It continues until maximum muscle recovery has been reached. It is invariably terminated within 18 months. From a practical point 6 months covers the significant improvement. The recovery phase is followed by the residual stage. Treatment during the first of these two stages is based on the underlying pathology. When the acute stage is passed, the patient is left with the damage incurred by the motor columns as a result of the virus invasion. Attention is brought to the use of hot fomentations in 1903 by Kellogg and 1916 by Lovett. In evaluating three reported series using the Kenny treatment, the author finds "when viewed in the cold light of their own figures, one has difficulty accepting the Kenny treatment as the epoch-making contribution it is supposed to represent". Prostigmine and curare have been tried, but except for possibly some relief of pain, they can have no direct effect on the course of the disease. No measures proposed to date give other than symptomatic or supportive treatment for they are all directed toward the secondary manifestations and do not affect the amount of nerve cell damage. In discussing comfort, the author indicates that all these patients are not writhing in pain and if allowed to lie quietly in bed, they are comfortable.

The prevention of deformity is of utmost importance and position of function is maintained by hard bed, pillows, sand bags and splints. Exercises are begun under water through the range permitted by active motions. Passive motion is performed concurrently to maintain the full range of the joints. Ambulation is determined by the comfort of the patient. When weakness of a part requires it, braces will be necessary. During recent epidemics, the trend has been towards over-treatment and the over-expenditure of funds that should have been directed to scientific research.

The residual stage requires highly specialized skill and entails correction of deformities, arthrodesis for stability and improved function and muscle transplants to improve function and alleviate deforming forces.

An article by Pohl (65) from the Elizabeth Kenny Institute lays claim to having prevented deformities in acute poliomyelitis by treatment of the muscle spasm and shortening, which are accredited to direct attack of the poliomyelitis virus on muscle and facial tissues. This article accepts the premise that the complications of poliomyelitis are primarily due to this mechanism. It accepts the finding of central nervous system involvement, but minimizes this factor as a cause of deformity. The series of cases (1057) presented, of which 1048 were discharged "free of gross deformities" contained 395 "incipient deformities" at the height of the disease. These observations are the basis for the assertion that "the disease in the peripheral tissues rather than unbalanced pull of muscles causes deformity".

Litman and Bosma (66) studied the past growth of 133 children contracting poliomyelitis in the 1946 Minnesota epidemic. These were compared with siblings and classmates by use of the Wetzel Guide for Evaluating Physical Fitness. The authors' findings imply that, other things being equal, susceptibility to poliomyelitis is increased by conditions leading to unsatisfactory growth, that factors associated with poor growth predispose to poliomyelitis attack; that the disease is rare among children of stocky build; and that the disease is rare in the pre-pubertal stage of development.

The basis for inequality in leg length in poliomyelitis is discussed in detail by Barr (67). The average skeletal age for cessation of longitudinal growth of the femur and tibia is 14-3/12 years in girls and 16-3/12 years in boys. The causes of unequal growth and leg length are due to (1) local interference at the epiphyseal plate (congenital abnormalities, tumors, infections, trauma); (2) interference from remote causes (poliomyelitis; spastic, obstetric and traumatic nerve palsies; and disease such as caused by casting in tuberculosis and Legg-Perthes disease); and (3) factors stimulating unilateral growth (osteomyelitis, hemangioma, arteriovenous fistula, diaphyseal fracture). About 1/3 of the patients with poliomyelitis, treated as out-patients at the Massachusetts General Hospital, with onset before the age of 16, developed marked inequality in leg length. The factors effecting this result are age of onset, sex, and the amount and distribution of muscular weakness in the legs. There is no shortening if the involvement is symmetrical. The greatest shortening occurs in younger patients with one normal and one severely paralyzed leg, and is more severe in the male.

To equalize length of legs in adults, a raised heel is used to correct discrepancies of 3/4 to 1-1/2 inches; if more than 1-1/2 inches of shortening is present, the sole must also be raised. Femoral lengthening was first tried in 1905, but the operation is formidable and complications frequent, especially loss of knee function. Tibial lengthening is now rarely done, because it has many dangers. Shortening of the normal limb can be done by femoral or tibial shortening. Equalization of leg length in the growing child has been attempted in several ways. Years of plaster cast immobilization should be avoided. The insertion of ivory pegs into or near the epiphyseal plates, and juxta-epiphyseal drilling are ineffective methods. Sympathectomy to stimulate growth has been done with promising results; it is not valuable after the age of 12 or 13, or if marked shortening has already occurred. Retardation of growth of the longer leg by operative arrest of growth of one or more epiphyseal plates has been accomplished, usually about the knee joint. Medial and lateral portions of the epiphyseal plates are excised and replaced by bony blocks. Deformities of the knee occurred in 5.6% of one series of cases, and 11% of another series. 10% of one series required secondary operation. The operators claim success in 90% of cases with this operation. Irradiation of the epiphysis holds definite promise.

Barnes (68) has outlined the treatment he utilizes for all the phases of poliomyelitis. For the acute stage he recommends careful general medical care with adequate food and fluid intake. Physical therapy, consisting of movement of involved joints through the full range of motion, three times a day, and hot packs is begun. The hot packs he has found do not always give their reputed beneficial effects. For spasm he has used intravenous novocaine, 10 mgm per pound of body weight, once in 24 hours. Intensive physical therapy is given in the subacute stage with daily exercising of all muscle groups. Deformities are prevented or minimized by the use of braces. In the chronic stage, surgery is performed if necessary, after two years, or after maximum physical therapy has been achieved. He points out that braces as a rule are not designed to correct deformities, but merely prevent its occurrence or progression.

Lowman (69) discusses the orthopedic surgeon and his co-workers, and here again, the author states that team work is most essential in the

treatment of poliomyelitis. Without it, the patient is inadequately treated and as a result will develop deformities which would be most difficult to correct.

Wood (70) reviews the treatment of poliomyelitis from the orthopedist's point of view by dividing it into three stages. He states that the three aims of treatment are alleviation of pain and muscle spasm; prevention of contractures and deformities, and restoration of function as near normal as possible for that individual. The author reiterates the various physical therapeutic measures that are beneficial and the complications of the disease that should be guarded against.

Mustard (71) describes the orthopedic care during the convalescent stage of infantile paralysis. He states the Orthopedist must rely on the Neurologist, Psychologist, Physiatrist, Physiotherapist, Occupational Therapist, and Play Therapist, for aid in the successful management of this disease.

An article by Ingersoll (72) presents an interesting group of cases in which the peroneus longus tendon has been transplanted for a paralyzed anterior tibial. The surgical technique is outlined. The operation in all cases now is performed only after a triple arthrodesis has been done. No transplant is performed unless the anterior tibial is completely paralyzed. The foot is always placed in slight valgus following operation. The convalescence is shortened to three weeks. All operative procedures are followed by guided physiotherapy.

Milgram (73) presents a discussion of the procedures necessitated by loss of deltoid, elbow flexors, and wrist extensors following poliomyelitis. To stabilize the shoulder, he recommends arthrodesis and resection of distal one-third of clavicle. A fibrous arthrodesis in the very young is acceptable followed later by bony fusion. The arthrodesis should never be done with the shoulder in external rotation. Palsied elbows he finds can be improved by the Steindler flexor-plasty operation, and for the loss of the wrist flexors he suggests arthrodesis.

Cooksey (74) discusses the role of Physical Therapy in the treatment of poliomyelitis. He emphasizes the importance of early and correct diagnosis stating that in a series of 104 cases studied by McAlpine et al 44 were erroneously diagnosed as poliomyelitis. He divides the treatment of poliomyelitis into three stages. First, the inflammatory phase, in which the first consideration is saving the patient's life and in giving the patient proper rest. He advocates the use of hot wet packs, to be applied not more often than 4 times daily, and splints and a hard bed to rest muscles and joints in the neutral position. He moves the joints through a full range of motion once or at most twice daily to prevent contractures. He feels that by and large patients are over treated in the early stage and he definitely states that the hot packs as recommended by Kenny tend to interfere with the patient's rest. The second stage or stage of potential recovery, lasting from a few weeks to two years, is the phase in which Physical Therapy assists in the recovery of paralyzed or weak muscles within the limits determined by the permanent damage in the central nervous system. In this stage re-education exercises and re-establishment of coordination are of prime importance. The

third stage is described as the stage of chronic disability, during which reconstructive surgery, appliances and vocational training are used to obtain maximum function of the individual. It is this third stage that maximum efforts on the part of all concerned is required.

Kottke, Teigen et al (75) compared hot packs, curare and placebos in an effort to determine which if any was best as an adjunct to stretching of tight muscles affected with poliomyelitis. They concluded that objectively, no difference in the time required for a muscle to regain its normal resting length could be determined when using stretching alone, stretching plus curare, stretching plus hot packs or stretching plus placebos. They assumed first that stretching of unaffected muscles was necessary to restore normal resting length on polio muscles. On this assumption they found that the most important factor in determining return to normal length was whether or not the muscles were paralytic or non-paralytic. Normal length was established in the non-paralytic muscles from 2 to 4 weeks whereas the paralytic group length was restored in a much longer time.

Watkins (76) states that the major aim of treatment for the patient convalescing from poliomyelitis is the salvaging of all available neuromuscular elements. He shows that the measures utilized are in the field of Physical Medicine. Recent research particularly electromyographic studies are quoted to show that a quantitative and scientific basis for the various modes of Physical Therapy are being established. He also briefly outlines the newer technics in field of treatment of poliomyelitis, chiefly, the use of progressive resistive exercise as described by De Lorme for strengthening weakened muscles.

DeLorme et al (77) show that the remaining innervated muscles following an attack of poliomyelitis respond to progressive resistive exercise by an increase in strength and work capacity in much the same manner as normal muscles. In studying a group of 27 affected quadriceps muscles in patients who had the disease 1 to 49 years prior to the study, it was found that strength and work capacity increased in all muscles put through progressive resistive exercise.

NEUROMUSCULAR STUDIES

Shaber et al (78) reporting on 20 patients describe the technic they developed in stimulation of poliomyelitis affected muscles by means of a special current generator. Daily, each muscle or muscle group was stimulated for a period of 10 minutes or until fatigue occurred. They determined that unless tension is secured in the paralyzed muscle, electrical stimulation is not effective.

Huddleston and Golseth (79) by electromyograph studies on 330 paralyzed and paretic muscles in 20 cases of poliomyelitis determined that this type of study is of diagnostic and prognostic significance. The character of the various wave forms found in poliomyelitis affected muscles is described. Certain conclusions regarding diagnostic and prognostic findings are outlined.

(Ed. note: This is an important paper in that it describes basic research in the relatively new field of electromyography. It is felt by many that the

electromyograph will eventually be as important in the study of neuromuscular disorders as the electrocardiograph now is in the study of heart disease).

Hodes (80) studying 22 patients in the convalescent stage of poliomyelitis, determined electrical activity of parietic muscles before and after the "closed manual neurotomy" method of Billig. No muscles studied had changed in power for at least one year. He found that muscles showing no electrical activity prior to neurotomy continued to be electrically "silent" after neurotomy. Muscles which were electrically active prior to neurotomy produced potentials whose average amplitude was 22% greater than their respective control values 8 months after neurotomy. The neuromuscular block observed in the patients studied was either abolished or markedly reduced after operation (neurotomy).

By use of electromyography, Hodes (81) determined that there is a linear correlation between conduction velocity of the fastest nerve fiber in the residual innervation of a poliomyelitis weakened muscle and the maximal electromyogram obtained from that muscle. He further determined that the degree of paralysis in a muscle affected by poliomyelitis could be estimated by comparing the electromyogram from that muscle with the electromyogram of a corresponding normal muscle. He postulates that there is a selective viral destruction of motoneurons having axons of greatest diameter.

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SECTION 7

NEUROMUSCULAR DISORDERS EXCLUSIVE OF POLIOMYELITIS

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Physiology of Neuro-muscular Junctions

Welsh (1) gave introductory remarks to a symposium on physiology of neuro-muscular junctions, in which he briefly sketched the evolution of mechanisms of communications between cells. Multi-cellular animals have need for coordination of activities of their many cells and organs. The primitive system of coelenterates with long processed sensory cells is described. The author briefly discusses cephalization and alignment of cell processes into nerves. Along with the development of the nervous system there was evolved the endocrine system. The endocrine system is a kind of "broadcasting" system in contrast to the nervous "telephone exchange". Of the chemical substance produced by the nervous system in invertebrates and apparently involved in junctional transmission acetyl choline is the best known. Acetyl choline and cholinesterase can be found in the nervous tissue of the flat worm. It can be shown in leeches that nerve to muscle impulse transmission is chiefly a chemical event while in arthropods it appears to be electrical. The question arises - are there two strictly independent modes of junctional transmission - chemical and electrical - or are chemical and electrical events interwoven, with one or the other more easily demonstrable at the particular junction being investigated.

Kuffler (2) discusses the "transmitter" problem, i.e., events that take place between the arrival of a nerve impulse at junctions and the subsequent setting up of a muscle impulse. The following sequence is presented to explain "transmitter":- nerve impulse - transmitter - end plate potentials - muscle impulse. The author discusses some of the characteristics of the end-plate which has become a physiological entity. Duration and intensity of the "transmitter" is analyzed. The current theory of acetylcholine transmission is briefly discussed. Experiments on current flow in the terminal nerve region on the transjunctional region are presented. Potential changes were recorded from end-plate regions of isolated preparations while stimuli were applied within 0.5 mm. to the nerve nearby. Sub-threshold depolarization of the nerve terminals by applied currents or by blocked nerve impulses did not affect appreciably the end-plate membrane. Neuromuscular delay periods are discussed relative to current spread from nerve to muscle.

The author concludes that:

- (1) Action currents in the terminals are not effective in polarizing the end-plate region.
- (2) The "transmitter" action occurs during the breakdown in the terminals. The breakdown period is too short to account for the analyzed "transmitter" duration. Prolonged polarization

in the terminals does not prolong the transjunctional potentials. It is believed that during the "breakdown" in the nerve terminals the ions that are liberated could account for the observed phenomena.

The author cites a communication from Dr. Eccles which states that the electrical hypothesis cannot be reconciled with recent work. Eccles and his co-workers favor acetylcholines as the sole mechanism in neuromuscular transmission.

Muscle Relaxants

Edwards (3) states that muscle relaxant drugs have great possibilities in clinical practice. The ideal muscle relaxant is defined as one easy to administer, having the effect directly proportional to the dose, reversible in action and having no side-effects of any kind. The pharmacological action of the dextro-tubo-curarine and allied compounds is described. The pharmacological action of myanesin is mentioned. As an aid to diagnosis, curariform drugs have been found of considerable value. In myasthenia gravis as little as one-fortieth of the normal dose will elicit an exaggerated effect, even to respiratory failure. Curarisation has been found useful in the differential diagnosis of painful muscle spasm, especially in backache. If the pain is due to spasm it is instantly relieved by curarisation while pain due to root irritation is unaffected. As an adjuvant to anaesthesia curare is recognized as invaluable. In shock therapy of psychotic states curarisation before the convulsions does much to prevent the bony and soft tissue injuries. Muscle ruptures are less likely to occur since the violent contractions are prevented. Curarisation in the acute phase of poliomyelitis has been used to relieve the tightening of the antagonistic and synergistic muscles and thereby allow the affected part to be held in the optimum position. The best therapeutic results have been reported in convulsive states. Both tubocurarine and myanesin have been used. It has been used in idiopathic epilepsy, tetanus, Parkinsonism, cerebral palsy and traumatic, arthritic, or postural muscle spasm. The possibilities of further employment of muscle relaxant drugs are discussed.

Berger and Schwartz (4) report on oral myanesin in treatment of spastic and hyperkinetic disorders. Because of the properties of "myanesin" to relax spasticity and rigidity, its action to restore deranged reciprocal innervation and its inhibiting effect on certain release symptoms, suggested that the drug might be useful in the treatment of certain spastic disorders. Other investigators using this drug obtained short lived beneficial effects with intravenous use of the drug. Certain undesirable side effects such as thrombophlebitis and hemoglobinuria were observed. The purpose of this report is to draw attention to the fact that "myanesin" is well absorbed after oral administration and to outline briefly the satisfying results obtainable in previously intractable conditions. The drug was administered as a 3.3 percent solution in 20 percent aqueous propylene glycol with syrup of cherry 20 percent.

Hemiplegic patients showed a striking recovery of some of the voluntary movements of the paralyzed limbs ten to twenty minutes following administration. Remarkable results were also obtained in certain cases of cerebral diplegia. The drug appeared effective in spastic, athetoid, and choreiform

types of the disease. The favorable effect of myanesin in diplegia is due to the depressent action on the nuclei of the brain stem and to its power to reestablish disturbed reciprocal innervation. Myanesin also proved effective in various conditions causing muscular spasm such as subacromial bursitis, low back pain, and osteoarthritis of the hip joint. Patients receiving the drug should be watched closely since the chronic effects of the drug on human beings is still unknown. Generally speaking the principal use of myanesin remains that of abdominal surgery.

Mallinson (5) describes the mode of administration of myanesin for different age groups and different surgical procedures. Aside from surgery, myanesin has been used medically for spastic conditions and tetanus. It has been suggested that myanesin causes increased bleeding. The author does not substantiate this finding nor was he able to show increase in hemolysis. There is no question in the mind of the author of the efficiency of myanesin as a muscle relaxant under light anesthesia. The dangers of curare and myanesin are compared and it is concluded that hazards of curare are greater than those of myanesin.

In correspondence to the editor Gottlieb (6) reports a case of paralysis agitans of four years duration treated by injection of d-tubocurarine chloride in oil. When reaction to the drug was favorable (usually on 30 mg.) the clinical picture of relaxation to a drunken state for two hours occurred. Gradually generalized weakness developed and lasted for two days. At the end of this time her strength gradually returned and her walking improved to the state of being unassisted for the first time in four years. There was however, no change in her tremors. The improvement lasted two to seven days. Comparison is made of this experience to those of Drs. Clark and Hotston. The author was impressed with the apparent unstableness of the drug.

Recent reports indicated that curare might offer valuable aid in the amelioration of spastic paraplegia and paraparesis. Thirty four patients on the Paraplegia Service of the Cushing Veterans Administration Hospital were selected as spastic problems by Kuhn and Bickers (7). The group was divided into two groups of seventeen each, and an attempt made to distribute them evenly according to level of lesion and severity of spasm. One group received intramuscular injection of 175 mg. of d-tubocurarine chloride in oil and white wax every forty-eight hours for 10 doses; the other group of seventeen were given an equal volume of physiological saline solution intramuscularly throughout the same period. The observers and patients were intentionally kept unaware of patient distribution during the study. The observers were not able to estimate correctly the patients receiving d-tubocurarine. Of the total of thirty-four, 16 were judged incorrectly. No beneficial effects relating to the relief of spasms in paraplegic or paraparetic patients were obtained by intramuscular injection of d-tubocurarine in oil and white wax. The role played by suggestibility in therapy of this type of patient was clearly demonstrated.

Cooper and Hoen (8) administered curare in the form of intocostarin to 8 patients with marked spasticity resulting from spinal cord injuries. In doses that produced side effects necessitating discontinuance of the drug, no appreciable lessening of the muscle spasticity was noted. Intocostarin was noted to have no effect on the hypertonic urinary bladder.

Schlesinger (9) reports on pharmacological agents in the treatment of neuromuscular disorders. Cerebral palsy is frequently seen in crippling degrees which are refractory to physical therapy. Attempts at exercise will often increase the degree of severity of this abnormal state. The advantage of drug therapy is in its ability to ameliorate these mechanisms and allow purposeful therapy. Curare has interesting potentialities in the treatment of spasticity. The drug brings about a blocking effect at the myoneural junction. By maintaining certain concentrations of curare it is possible to create a differential block and, in effect, filter the abnormal volleys of nerve impulses. Tubocurarine in wax and peanut oil seems useful in maintaining low blood levels over long periods of time. An attempt is made to saturate the patient with curare at levels that do not interfere with voluntary function but do reduce the hyperactivity of the stretch reflex. Thus the voluntary power is unmasked and retraining is made possible in order to rebuild muscle volume and useful habit patterns.

Other drugs that have possibilities in this field are diparcol, myanesin, and parpanid. Diparcol is useful in true rigidity but its value in the mechanisms seen in cerebral palsy is not yet clear. Myanesin, a brain stem and spinal cord depressant, is efficient in reducing spasticity, rigidity, and involuntary movement. Parpanid is of interest in the treatment of rigidity and tremor of the Parkinson state. The authors state that in their hands, prostigmin has been of no value. Certain axioms are pointed out.

1. Drugs will only ameliorate abnormal mechanisms. They will not restore normal habit patterns.
2. Drug therapy is more useful in the younger age group.
3. Drug therapy should make the outlook of the physical therapist more optimistic and her task less formidable.

A British Firm has produced a synthetic paralyzant acting like curare-myanesin. Musgrove (10) reports the use of this drug in 200 cases. In most of these cases, abdominal relaxation was an essential surgical requirement. Dosages and techniques of administration are described. In this series of cases myanesin proved to be a very good muscle relaxant. When given in adequate dosage it compared favorably with curare. Myanesin produces less respiratory depression.

Peripheral Nerve Injuries

In a nerve trunk, which is the unit with which the clinician deals, there are many different fibers and their resistance to trauma varies so that resultant syndromes are innumerable. Roaf (11) divides nerve injuries into four classes:

- (1) Complete section - solution of continuity and separation of the proximal and distal portions to such a degree that spontaneous recovery cannot occur.

- (2) Partial section.
- (3) Transient lesions - the nerve has suffered temporary "concussion" and can recover spontaneously.
- (4) The nerve is being subjected to continuous compression which, if left untreated, will inhibit recovery and may ultimately lead to section. "Neural compression" is suggested as a convenient short name for this syndrome.

If all causes of continued compression have been removed; if there are no important complicating factors, such as ischemia and sepsis; if the peripheral end-organs are in good condition; and, if the patient is cooperating in his own re-education, a nerve which shows no recovery after three or four months has probably been divided (completely or partially) and requires surgical intervention.

Pollack (12) reports on the Peripheral Nerve Registry, established during World War II, in the Office of the Surgeon General of the Army, which permitted follow-up studies on peripheral nerve lesions. The problems posed to the Subcommittee on Neurosurgery of the National Research Council at the beginning of the War concerned the causes of nerve injury, the prevention and treatment of infection; the methods of joining severed nerves, including bridging gaps; the use of various types of sutures and glue; the effect of delay in suturing; studies of the effects of nerve injury, paralysis, anesthesia, atrophy, contractures, ulcerations, and sweating; studies of the microscopic appearance of nerves and muscles to learn the effect of infection, of various types of treatment, and of operations; development of methods of treatment of wasted muscles and contractures; studies of the effect of treatment by drugs, vitamins, and so forth; and improvement of old methods and development of new ones for ascertaining when a nerve was torn apart or was growing satisfactorily. Some of these problems were solved but several remain unanswered.

Compression and Severance of Nerves. Varying degrees of compression produce a characteristic form of paralysis dependent on the force of compression and length of time exerted. The effects range from temporary motor paralysis with rapid recovery to early paralysis and gross defect in sensation. It was shown that under such conditions, in the peripheral portion of the nerve, there was no disappearance of fibers but only loss of myelin sheath. Because the nerve remains connected, no muscle wasting occurred.

Results of Nerve Injuries. After sensation is lost, adjacent nerves at the borders of sensory loss grow into the anesthetic areas, and recovery of sensation may occur. After nerve severance the muscle atrophy that occurs has been known to be associated with fibrillation. It was proved that fibrillation is not the cause of atrophy. In cases of nerve injury, sweating ceases and the electrical resistance of the skin becomes increased. By means of an ohmmeter these areas of sweat loss can be outlined.

Electrodiagnosis. Investigations were unsuccessful in devising methods to differentiate between injuries by compression or concussion and those associated with severance of the nerve.

A number of devices for stimulation and measurement were invented and many important observations were made on conduction and conduction velocity.

Treatment. It is the consensus of opinion in this country that the earlier an injury to a nerve is repaired, the better is the opportunity for good recovery. Studies were made on suture material, glue, various tubes, and cables of fibers. Further evidence is required regarding the value of nerve grafts in human cases.

Microscopic Evidence of Regeneration. When, at operation, a gap between the severed nerve ends is found, there is, if sufficient time elapse has occurred, evidence of some regeneration in the distal segment. It is the opinion of most investigators that the new fibers in the distal segment find their way from the proximal segment. There still exists differences of opinion, however, on this so called "spontaneous regeneration" of the distal segment.

Seddon (13) gives a review of work on peripheral nerve injuries in Great Britain during World War II.

Classification of Nerve Injuries:-

1. Neurotmesis - In this condition the nerve is completely disorganized, although it may appear to be in continuity. All essential elements are interrupted and there is complete degeneration distal to the lesions. In lesions in which the nerve may be blocked by interneural scar tissue, the only effective treatment is resection and suture.
2. Axonotmesis - The axons and their sheaths are completely interrupted, but the internal architecture of the nerve is preserved, in particular the endoneural tubes. There is complete peripheral degeneration which is spontaneous, and the quality of recovery is very good since the outgrowing fibers remain in the tubes to which they belong. Restoration may be confidently expected.
3. Neurapraxia - The axons remain in continuity, but the myelin sheaths, especially those of the larger fibers, are interrupted. There is dissociation paralysis but no reaction of denervation in the affected muscles. Recovery is rapid and complete.

The major difficulty is to distinguish neurotmesis and axonotmesis since the clinical picture is identical. Neurotmesis occurs in open wounds and it is desirable to explore all nerve lesions, due to open wounds as soon as possible after wound healing. Closed nerve injury as in fractures are found to be axonotmesis in 4 out of 5 cases. It is here justified to delay exploration until it is determined that spontaneous regeneration is overdue.

In estimates of rate of nerve regeneration, for practical purposes, it is safe to expect an overall rate of 1mm a day.

Comparison of primary nerve suture with early secondary suture indicates that the delayed operation is preferable. If a secondary operation is done in three or four weeks after injury, the extent of intraneural damage is easily detected on reaction of the nerve ends. After a delay the sheath hypertrophies and will hold sutures well. Nothing should be done to the nerve, aside from bringing the ends together at the time when the primary suture of the skin is performed. It is possible to close gaps up to 17 cm by mobilization of the nerve stumps and suture with joints in acute flexion. In general flexion of knee or elbow beyond a right angle is unjustifiable. Homogenous grafts have been uniformly unsuccessful. At present the only hope lies in autogenous grafts which have their limitations. There is a significant fall in the proportion of good results where the delay between injury and repair was greater than six months. There was also a smaller proportion of satisfactory recoveries where the length of resection exceeded 5 cm.

(Ed. note: It is the consensus of opinion in the United States that the earlier an injury to a nerve is repaired, the better is the opportunity for recovery.)

Meyerding (14) reports two cases of traumatic sciatic paralysis complicating fractures of the acetabulum with posterior dislocation of the hip. This type of injury occurs when the patient is thrown against a car dashboard in the sitting position. The fracture fragments may cause immediate nerve damage or there may be nerve damage due to the hematoma or callus. With evidence of traumatic neuritis, immediate surgical intervention is recommended to prevent irreparable nerve damage. When treatment is delayed the scar tissue makes reduction of the dislocation very difficult, furthermore, surgical treatment may fail to relieve the nerve injury.

Riesenman (15) presents two case histories as examples of mechanical or pressure neuritis - one of sciatic neuritis secondary to abnormal posture and the second case, a median nerve "pressure neuritis" ("occupational" or "dental neuritis"). Mechanically induced neuritides make up a large percentage of the etiologic types of neuritis seen by the clinician. The nerves most often involved are the radial, ulnar, median, sciatic and peroneal. The author discusses the various specific causes of pressure neuritis under the main headings of occupational, recreational, or postural. The therapeutic regime should consist of measures directed toward the alleviation of symptoms. The symptoms consist of sensory, motor, and trophic factors appearing singly or in combination. Successful treatment takes into account certain principles which can be laid down for practical guidance:

1. Removal of the determining factor when known and amenable.
2. Provision of rest for the affected part.
3. Maintenance of neuromuscular nutrition as far as possible by warmth, massage, and electric modalities.
4. Prevention of deformities and other sequelae due to contractures, adhesions, fibrous growth, arthritic change, and trophic change, generally.

The importance of a detailed history referable to the circumstances under which the palsy develops is stressed in order to arrive at a diagnosis of "pressure neuritis".

Diddle (16) reports a case of paralysis of the serratus anterior muscle in a parturient. This case is that of a 23 year old white primipara seen four months post partum. Pain in the right shoulder, fatigue and weakness of the right arm had begun 24 hours after normal delivery. Pulling straps had been employed during delivery. Whenever the right arm was hyperextended or abducted, the scapula rotated outward. The patient received diathermy and massage over a six weeks period along with 10 mg. betalin twice daily. The pain, weakness and deformity gradually disappeared and muscular strength returned to normal. The author discusses briefly the history of the disease and the several methods of treatment which have been advocated. Since the end results obtained by operative measures are not always satisfactory it is recommended that conservatism be practiced.

According to Bailey, (17) to justify a diagnosis of neuritis there must be a loss of function, either motor or sensory. The term "neuritis" is used rather loosely by the profession. Neuritis may be caused by a variety of injuries, many of which are preventable. The author presents 8 cases of neuritis to show the importance of pressure as a cause of neuritis. Treatment consists of rest during the acute phase, splints to prevent contractures, and galvanic stimulation to prevent atrophy. Active exercises should be started as soon as movement begins.

Cerebral Palsy

Collis (18) emphasized that the child with cerebral palsy is not essentially a deformed or mentally retarded child. The important thing is to begin treatment before deformity or mental deprivation have occurred. In cerebral palsy one of the control centers in the brain is damaged - if this is the cortex, the result is spasticity; if the basal ganglia, the result is athetosis; if cerebellum, the result is ataxia; extensive damage is likely to result in rigidity and tremor together. Where one part only is damaged the treatment aims at "by-passing" the damaged control center in order to produce a more normal child. An attempt is made to teach a different cerebral control of musculature from that which is normally controlled by the damaged section of the brain.

Phelps and St. James (19) discuss the prevention of postural deformities in children with cerebral palsy. Because of its complexity it should not be expected that one drug, one type of brace, certain surgical procedures or a routine set of exercises can result in a spectacular response in cerebral palsy. Cerebral palsy includes five primary classifications - spasticity, athetosis, ataxia, tremor and rigidity. Under these five classifications are several sub-classifications. Cerebral palsy may be defined simply as a lack of motor control, but one must recognize the multiple variances in order to realize that one or two principles of treatment cannot be suited to every situation.

Since certain types are prone to deformity it is essential that an accurate diagnosis is made and preventive measures instituted early. The spastic type is most prone to deformity because of muscle imbalance. The patients with rigidity are next most susceptible to deformity due to lack of contractility of muscles with fixed posture. The tension type athetoids are apt to acquire deformity as a result of prolonged postural attitudes plus the tension which favors certain muscle groups. Patients with tremor show little or no tendency to deformity. Those with ataxia demonstrate relaxed ligaments and hypermobility most noticeable on weight bearing.

After diagnosis is established, an accurate muscle analysis should be made to determine any imbalance about a joint. Braces for cerebral palsy differ from those in poliomyelitis since, in the latter, the problem is one of weakness. Stronger braces are needed in cerebral palsy to overcome muscle strength. In planning bracing it is necessary to consider all factors involved and, if necessary, err in bracing too extensively rather than insufficiently. Bracing for the upper extremity is not usually so extensive as for the lower extremities. The braces should be checked frequently to see that they fit properly. A program that will encourage good postural habits over extended periods is essential. A carry-over to night braces assures good preventive measures against deformity.

Surgery, in cerebral palsy, has a definite place, but is limited in scope. Athetoid conditions are contraindications for surgery in most cases because of the athetoid shift. Careful and accurate evaluation is necessary before surgical procedures are done.

Certain drugs are used in selected cases of cerebral palsy. These drugs are chiefly the relaxant types. Prostigmine has its most beneficial effect in rigidities and tension athetosis. Curare is a paralytic drug which must be employed with discretion and under close supervision.

Many cerebral palsy children present serious feeding problems because of their difficulties with chewing and swallowing. Because of the tremendous exhaustion of energy in the athetoid type increased food intake is necessary. Spastic children being more sedentary require less than the average diet.

It has become clearly apparent to those working with cerebral palsy that specialized forms of physical therapy offer the best means of treatment for the child with cerebral palsy. Surgery offers limited possibilities in special selected cases. Drugs have value only as adjuncts to physical therapy. The physical therapy measures used in cerebral palsy are entirely different from those involved in disease or injury to the spinal cord and its roots. The problems of cerebral palsy include paralysis, spasticity, rigidity, ataxia, tremor and incoordination, with multiple combinations. There are also speech, hearing, visual understanding and mental defects which further complicate the picture.

The meaning and value of postural reflexes, reactions of defense, tonic neck reflexes and pattern movements, which are all vital considerations in the majority of patients suffering from cerebral palsy, should be familiar at least in their clinical aspects. Fay (20) describes the various defense reflexes that may occur and the development of pattern movements. In the past, these basic reflexes of automatism have been considered an undesirable problem that plagued the therapist as well as the physician-in-charge. Organization of these reflexes and utilizing them for purposes of developing muscles, relaxing antagonists and coordinating tone have resulted in definite improvement. These reflexes have been made to fit into pattern movements with great improvement in spasticity.

Many pattern movements originating in the lower motor levels of the mid-brain, the medulla and the upper cervical and thoracic portions of the cord offer a challenge to the therapist to determine whether it is possible that certain automatic spinal reflexes can be organized and coordinated with what remains in the higher cortical centers and bring about pattern movements.

Position is a point of extreme importance. If the patient is lying flat on his back there will be increased tone in all the extensor groups that are being treated when attempts are made to produce flexion. If the patient is turned on the abdomen, an immediate reverse of tone effect (through the labyrinth) may be accomplished and a great deal of muscle spasticity will be diminished. Automatic reflexes latent in man may be utilized again in spastic paralysis at primitive levels of function to the benefit of the patient, and as an aid to the rehabilitation if properly augmented and trained.

The first requisite of braces in cerebral palsy according to Knight (21) is that the braces must be strong in order to resist the constant scissors deformities and to withstand the stresses of the athetoid and spastic. The cosmetic appearance of braces cannot be considered in cerebral palsy since functioning of the brace is of primary importance. The second requisite of the brace is to have joints which will work freely with the constant side thrusts and torsion. It is the author's experience that ball bearing type joints are best. In the athetoid the brace is used to control the deforming tendencies and to aid in training a pattern of motion. The brace of the spastic serves to maintain the extremity in good weight bearing position and to prevent the deformity thrusts. The braces should always be calipered so that the shoes can be put on in a knee flexed position and the brace later attached to the shoe. This method of application insures that the heels are well down in the shoes.

In treating cerebral palsy cases the policy is to defer surgery at least until the growth is complete. Braces are then a very important part of therapy.

Grayson (22) offers a method of testing for handedness. This paper does not attempt to go into the question of dominance with the various aspects that enter into the problem in cerebral palsy cases, but simply to

point out a few basic facts with which every therapist testing these cases should be familiar. Handedness testing cannot be successfully carried out on a child under two years of age, and it can be made with more certainty after the age of three. Both arms are treated and trained during the babyhood period unless there is a definite spastic hemiplegia.

Considerable study has been done on eyedness and its importance in relationship to handedness. In the majority of cases the dominant eye is on the same side as the dominant hand. Simple tests for determining eyedness are described. A test form for handedness testing is presented. In preference testing for handedness the therapist is cautioned to stand directly in front of the child and pass or place the testing material in the center position. Both the child's hands should be free to receive the object. The preference testing should be done 10 to 15 minutes daily for a period of a month and results should be tabulated. Various testing materials are listed.

Myasthenia Gravis

Although a somewhat rare disease, according to Viets (23), myasthenia gravis is not so rare as was believed ten years ago. There are probably 1500 cases in this country. There is only one symptom of myasthenia gravis - an exaggeration of normal fatigue of voluntary muscles. Up to 1935 the mortality rate varied between 50 and 75 percent - indeed a "grave myasthenia". At the present time the mortality rate is probably less than 10 percent.

There is always fatigue of the voluntary muscles, but early in the course of this disease certain muscles are more easily fatigued than others. The muscles that have to do with the eye and eyelid movements are most frequently affected. In 45 percent of the cases the first symptoms often are ptosis or diplopia. The second most important group are those with general weakness, fatigue in walking upstairs, difficulty in raising the arms and doing ordinary tasks. Another group, about 20 percent, have dysphagia and dysarthria. The age distribution of patients varies from the earliest years in life to well into the eighties. The patients most frequently seen are young adults or people in middle life. Prostigmine, now as neostigmine, has proven to be the drug that has the most marked therapeutic effect and the one that is used as a diagnostic test. Neostigmine treatment ~~is a~~ is a form of substitution therapy. There is a chemical dysfunction at the junction of the nerve and muscle; neostigmine is added to this myoneural junction and the chemical reaction is restored to normal, or partially so.

It has been observed at autopsy that the thymus gland was changed in some patients dying of myasthenia gravis. This observation has led to treatment by surgical removal of the thymus. The author is of the opinion that the results are just as good with neostigmine therapy. It is doubtful as yet whether thymectomy, which is still experimental, is of value in this disease or not. Thymectomy is to be advised in patients who have not done well under medical treatment.

Myasthenia is seen occasionally in adults, uncommonly in adolescents, and rarely in infants and young children. Bowman (24) presents case histories of three children, ages 3-7/12, 4-6/12, and 8-2/12 years, with myasthenia gravis who had been treated during the last three years at Boston Childrens Hospital. Photographs of the patients taken before and after the "prostigmin test" are shown. The authors summarize by stating that all infants and children having ptosis of the eyelids should be given the "prostigmin test". Myasthenic symptoms and signs were evident at birth in Case 1, and this is the first case of congenital myasthenia gravis to be recognized in the medical literature.

Bell and Perrin (25) report a case of a woman, aged 31, who developed myasthenia gravis. Symptoms were first noticeable during the seventh month of pregnancy. She developed weakness of the muscles of chewing and swallowing and also of her arms. There was marked ptosis of the eyelids. The patient was treated with prostigmine but her condition became progressively worse. Three months after onset of symptoms a diagnosis of a tumor of the thymus gland was made. The tumor was removed and the patient then showed a steady improvement and could be maintained on prostigmine 15 mgs. t.i.d.

The following points were made:-

1. The condition is frequently associated with Grave's disease.
2. These patients sometimes die suddenly with respiratory paralysis therefore they should carry a syringe and ampule of prostigmine for emergency.
3. The sensitive muscle group for diagnosis is that of the swallowing muscle.
4. The mode of action of prostigmine is to inhibit cholinesterase, thus permitting the normal function of acetyl-choline at the nerve synapse.
5. Surgical treatment of the thymus gland is the treatment of choice in advanced cases who are regressing even on large doses of prostigmine.

Troncelliti (26) reports a case of myasthenia gravis occurring in a 9 year old boy. The author states that he can find only 37 cases in the literature occurring under 17 years of age. The chief complaint in this case was bilateral ptosis of eyelids. There was a diplopia in the inferior field of vision. One year prior to admission there had been difficulty in breathing. The remainder of the physical and neurological examination was negative except for slight posterior cervical adenitis. The ptosis was more marked in the evening. On 0.3 gm of quinine sulfate extreme fatigue resulted so that the patient was too tired to count to 100. On 1 mg of prostigmine methyl sulfate the ptosis disappeared as did the tired sleepy feeling. The child's treatment was standardized on 15 mg of prostigmine bromide four times daily, and 8 mg of ephedrine sulfate twice daily. The total duration of the disease in this case at the time reported was 17 months.

Although myasthenia gravis is an unusual disease, the diagnosis can often easily be made because the patient presents a rather typical picture. The physiological disturbance seems to be at the myoneural junction. The outstanding features of the disease are the rapid fatigability of the muscles on activity and the quick restitution of function on rest. Ptosis, diplopia, dysarthria, dysphagia, along with general weakness are the presenting complaints. The diagnosis is based on the clinical picture plus the results of a test dose of prostigmine. (Prostigmine methyl sulfate 1.5 mgm. and atropine sulfate 0.6 mgm. and dramatic recovery of strength results within 20 minute.) Maintenance doses up to a total of 180 mgm. per day may be given but 15-30 mgm. every 3-4 hours is usually sufficient

Meredith (27) gives two case reports in detail. Case number one is that of a 44 year old railroad conductor whose disease was controlled on prostigmine bromide 37.5 mgm and atrophine sulphate 0.45 mgm every 3½ hours while awake. Case two is that of a 42 year old negro laborer who was controlled on 30 mgm. of prostigmine bromide and 0.45 mgm of atrophine sulfate every two hours during the day, and one dose at mid-night. In addition he was given 45 mgm. of ephedrine sulfate four times daily.

The subject of pregnancy in myasthenia gravis has received little attention in the literature and only a small number of cases have been reported. Harris and Schneider (28) review the literature and report a case of pregnancy in myasthenia gravis. The effects of pregnancy upon myasthenia gravis are discussed. A discussion of labor, puerperium, mortality, and infants born of myasthenic mothers is presented. In the one year post-partum follow-up of this case presented, there has been no improvement in the myasthenia gravis, but rather a slow downward progression. There was no decrease in the amount of prostigmine needed after delivery, in fact, dosage was gradually increased over the one year period so that the patient was taking between twenty-five and thirty 15 mg. tablets daily. The patient had been maintained on 90 mg. daily for the five years before pregnancy.

Eaton (29) gives a warning concerning the use of curare in convulsive shock therapy of patients with psychiatric disorders who may have myasthenia gravis. The value of convulsive therapy has become widely established in the treatment of psychiatric disorders, particularly the depressions. Furthermore, curarization preliminary to convulsive therapy is widely used.

Bennett and Cash (30) found that the weakness of patients with myasthenia gravis was greatly intensified by small amounts of curare. One tenth to one twentieth the usual dose will result in marked exacerbation of symptoms of a patient with myasthenia gravis. It is to be emphasized that quinine and curare diagnostic tests should not be used in patients who are seriously weakened, since further weakening may result in death. The ordinary curarization of a depressed patient, preliminary shock therapy might prove fatal should the patient also suffer from myasthenia gravis.

Myasthenia gravis is not nearly so rare as it was once assumed to be and it must be ruled out in any case in which curarization is to be used preliminary to shock therapy if tragedy is to be avoided.

Causalgia

Although certain aspects of causalgia have been described previously, it remained for Mitchell and associates (31) to describe the condition. The essential features were repeatedly confirmed with the passage of time. In certain details, however, variations were encountered.

Shumacker, Speigel and Upjohn (32) discuss the signs and symptoms and particularly the vasomotor status in a group of 90 cases studied by them. The upper extremity was affected in 49 cases and the lower in 41. The series contains no cases of complete paralysis in which widely divided and completely separated ends of the nerves were demonstrated at operation. Concerning the onset of pain the data is unreliable since in many cases the memory for such details during the first few hours or days of injury was hazy. Fifty patients said pain began immediately after injury; 23 from the first to the eighth day; 9 during the second or third week; 3 from one to two months; and one 4 months after injury. Four cases no data. All except four described "burning" as part of the characteristic of the pain. Forty cases described "burning" pain only. Almost without exception the pain was made more intense by the use of the part, and by touching or tapping the affected hand or foot. The pain was localized in the hand or foot in all instances; in a few it also extended up the forearm or leg.

In all cases an effort was made to evaluate carefully the vasomotor status. It was not always possible to perform all the circulatory tests desired; often the patients fear of aggravation of pain could not be sufficiently overcome to obtain his permission or cooperation. Twelve patients said the injured hand or foot was warmer than the contralateral one. Twenty-seven said the hand or foot was colder than the other. The other 51 patients thought there was no difference in temperature or that the involved extremity was sometimes warmer and sometimes colder. Thirty patients showed the affected extremity to be pinker than its mate. The hand or foot was cyanotic in 29 cases and pallor was noted in 5 instances. The peripheral pulses were not significantly altered except in cases of major artery injury, ligation, or thrombosis. Examination of data recorded reveals that in only a few instances was the skin temperature in the range of maximal vasodilatation. In nearly every case a distinct increase in warmth occurred after sympathectomy. Atrophy and contractions tended to be more severe in cases with arterial occlusion.

Most of the observations made by Mitchell, Moorehouse and Keen concerning the signs and symptoms of causalgia have been substantiated in the reported studies. In 86 of 90 cases, burning pain was present. The transient partial relief of pain from wetting the part was not commonly observed. Mitchell, Moorehouse and Keen originally found causalgia only in cases of partial nerve injury. It has subsequently become apparent that causalgia may occur when the nerve damage is apparently complete.

The glossy fingers, tapering, curving of the nails which occurred so commonly in the original account was present in only a small percentage of this series. Such changes were more frequent in impaired vascular supply.

It would seem that the physiopathological explanation of the pain of causalgia must take into account the fact that the pain may occur in the presence of increased, decreased, or relatively normal vasomotor tonus, as well as the fact that altering the vascular tone by any means other than by sympathetic interruption results in no effect upon the pain in the majority of cases. In a survey of recently reported experiences with over 300 cases of causalgia, no true case of causalgia has failed to respond to sympathetic block by a period of complete or nearly complete subsidence of pain.

The origin of pain and the pathways for its conduction remain an ill understood feature of neurophysiology. The causalgic state presents a challenging field in such studies. According to Threadgill (33) the essential lesion in this condition appears to be one of vascular and neural irritation resulting from wounds involving blood vessels or nerves.

A pathway of certain afferent impulses from the injured peripheral nerve to the cord by way of the sympathetic paravertebral structures will explain many of the bizarre findings of others reported in this paper and the effects of sympathectomy in relieving pain when vasospasm is not a factor. Reference is made to previous experiments by the author which showed that in unilaterally sympathectomized animals, when the posterior roots of the lumbosacral plexus were cut bilaterally, painful sensations were perceived by the animal only in the side where the sympathetic ganglia, trunk, and rami were intact. It was, therefore, deduced that painful stimuli were conducted via the grey communicating rami to the sympathetic ganglia. To explain the mechanism of causalgia, it is proposed that general visceral afferency is a functional component of the spinal nerve and that this pathway reaches conscious levels under certain conditions.

For some time it has been evident that interruption of the sympathetic pathways constitutes the most reliable, conservative, and safe method of treatment of causalgia. The recent war experiences which have been reported are in agreement concerning the general efficacy of sympathetic interruption.

Shumacker, Speigel, and Upjohn (34) made a study based upon observations on 90 patients who were thought clinically to be suffering from major causalgia. Most of the patients were studied at U.S. Army General Hospitals. Sympathetic ganglionectomy for the lower extremities was accomplished through an anterior extraperitoneal approach under spinal anesthesia. The upper extremities were denervated by the posterior pre-ganglionic operation of Smithwick, performed under intratrachial anesthesia. Fifty-seven patients were treated by permanent sympathetic interruption. Twenty-one responded well to single or repeated procaine sympathetic blocks. One hundred eighty-one sympathetic blocks were performed in 83 patients. Seven patients in the series received no sympathetic anesthesia because sympathectomy was felt advisable because of poor circulation or extensive nerve damage. In a few, relief of pain was incomplete.

In some of these the burning pain was relieved completely and the residual discomfort was that of tingling or aching. In the other instances the entire pain was dramatically relieved. The duration of relief varied. Seventy-eight blocks were followed by relief of pain for two hours or more. When each successive block resulted in a shorter period of relief, no permanent alleviation was achieved by further injections. On the contrary, those patients who were eventually rendered free of pain by procaine blocks generally noted progressively longer periods of freedom from pain following each successive injection. Of the 83 patients in whom sympathetic anesthesia was induced one time or more, 21 obtained permanent relief. Ten required only one injection.

Thirty-four patients were treated by permanent interruption of the sympathetic pathways in the upper extremities. Thirty-three by operation and one by alcoholic infiltration. The duration of pain at the time of operation ranged from 1.7 to 13 months, an average of 4.7 months. In 25 patients the pain was completely relieved and in six others the residual discomfort was inconsequential. All patients were followed for several months after operation and none had return of pain.

Twenty-three patients were treated by lumbar sympathectomy. The duration of pain at the time of operation varied from 3 weeks to 14 months, an average of 5.28 months. Relief of pain was complete in 11 patients and in another 4 patients an excellent result was obtained, the residual discomfort being trivial.

Of the 57 patients treated by operation (or alcohol injection) an excellent result was obtained in 46, or 81%. Detailed case reports are presented in the patients whose operative results were only good, fair, or poor.

This study confirms the concept that interruption of the sympathetic pathways constitutes the most reliable and safe method of treatment of causalgia.

In those cases in which there was incomplete relief of pain, several considerations must be taken into account. Four cases recorded obtained relief after excision of the first lumbar ganglion after incomplete relief following excision of 2nd and 3rd ganglia. Two cases obtained relief on reoperation to excise the 12th or 11th thoracic ganglia after having had excision of the lumbar chain.

Shumacker (35) makes an attempt to clarify the clinical picture and the treatment of causalgia. Causalgia was originally described by the following features: pain of varying intensity and predominantly burning in character, coming on some time after incomplete injury to a peripheral nerve, felt chiefly in the periphery of the extremity, exacerbated by touching the part, dependency, jarring, emotional excitement, dryness, and generally by heat, relieved somewhat by wetness and cold, associated usually with glossy, red, blotched skin, always comparatively increased in warmth, and leading in many instances to emotional instability. In certain details, further experience has revealed aberrations in the original accounts. The condition is prone to occur after injury to the median or sciatic nerve. In a total of 400 cases the upper extremity was affected in 238 or 60% of cases.

Mitchell, Moorehouse and Keen (31) were not of the opinion that the causalgia was immediate. Approximately 50% of the cases in the authors' experience stated that the pain was immediate, however, it is admitted that the patient's memory for details after such experiences may be inaccurate.

Though burning is the usual and characteristic type of pain, there are reports of series of cases varying from 4.4% to 45% of patients that did not have burning.

It is concluded that wet applications are by no means always effective in providing partial relief. Though warmth often helps those with vasoconstriction, and cold those with vasodilation, there are many exceptions. The pain is always felt most intensely in the periphery of the extremity and the pain is exaggerated by touching, noises, hunger and excitement.

The original belief that glossy skin is especially common in causalgia and that such changes never occurred in the absence of burning has not been supported by other studies. About one-third of the author's patients presented evidence of relatively normal vascular tonus. Most of the others had relative vasodilation though some had distinct vasoconstriction.

The essential diagnostic criteria of causalgia appear to be the presence of constant spontaneous pain following partial or, more rarely, complete injury to peripheral nerves, generally, but not always, predominantly burning in nature, exacerbated by certain stimuli, and capable of temporary, complete, or nearly complete alleviation during sympathectomy procaine anesthesia.

It is only within the past few years that results of large series of cases treated by sympathectomy are available for analysis. In a review of reported cases excellent results were obtained in 76.3%, good results in 21%, poor results in 2.7%. Excellent results are 82.9% in upper extremity and 65.6% in lower extremities. It is felt that the available data suggests that at least a small number of the incomplete cures or failures following sympathectomy are explainable on the basis of inadequate sympathetic denervation. There is general agreement concerning the efficiency of sympathectomy in the treatment of causalgia. There is, however, considerable disagreement concerning the usefulness of procaine blocks as a therapeutic measure. The author is convinced that certain individuals can be treated satisfactorily by blocks alone. If successive blocks give relief for the same or diminishing periods, one should abandon these measures and proceed with operation.

Sympathectomy should be done early, in causalgia, in order to prevent long continued suffering, to avoid narcotics and addiction, and to prevent damage to the affected extremity.

No theory, as yet offered, furnishes an entirely satisfactory explanation of pain of causalgia. The two most widely accepted theories are those of Livingston (36) and Doupe, Cullen and Chance (37). The author briefly reviews several theories of the mechanism of causalgic pain and concludes that none of the current theories is entirely satisfactory and that further intensive study is required.

The picture of causalgia is briefly described in its typical aspects by Gordon (38). In exceptional cases causalgia is observed without neuritis. A case is presented as an illustration of the existence of causalgia over the area of distribution of one single nerve, without trace of motor or objective sensory manifestation referable to that nerve. A forty year old woman, without history of trauma, developed, about two years ago, burning pain over the distribution of the ulnar nerve at the wrist and hand. The burning pain appeared in paroxysms many times daily. The hand temperature was variable during the paroxysms. There was no evidence of atrophy. Pressure on the main nerve trunk did not provoke neuritic pain. The result of treatment of this case is not discussed. The author places this case on record because of the absence of neuritic symptoms and lack of traumatic etiology. The modes of treatment procedures that have been employed in this disease are listed by the author.

Echlin (39) reports his observations on major and minor causalgia on a study of 1500 cases of peripheral nerve injury. It is concluded that major causalgia resulting from war wounds of large peripheral nerves is more common than has been reported. Pain is the central feature of causalgia; the vasomotor and trophic changes are variable and non-specific. The classical syndrome of causalgia is seen in its complete form only when the condition is at its height. The majority of patients with major causalgia showed a gradual spontaneous improvement so that as this improvement takes place, all gradations of intensity in the condition may be seen. During this period of improvement a case that at one time would have been classified as severe causalgia later might be termed a minor causalgia. On the other hand, some patients may present the picture of minor causalgia without passing through a phase of major causalgia. Realization of these minor forms is important since the condition is probably more common than is generally recognized. Regardless of the intensity, the same abnormal mechanisms are apparently operative. Even though gradual improvement may take place over a long period of time, the irreversible changes that take place in the tissues and the emotional disturbances of the patient dictate that the condition be treated early. Sympathectomy should be effected in severe causalgia if a sympathetic block has given temporary relief and, under such conditions, brings about cure to the majority of patients.

Toumey (40) reported on 31 patients with reflex sympathetic dystrophy, treated by sympathectomy, who were seen at the Lahey Clinic from July 1944, to July 1947. Reflex sympathetic dystrophy is a disturbance of the sympathetic nervous system, characterized by pain and sympathetic phenomena which may follow major or minor traumata. The most prominent feature of reflex sympathetic dystrophy is chronic continuous burning pain. Characteristic sympathetic phenomena also appear, most commonly vasoconstriction but there may be vasodilatation. Objective signs which indicate the syndrome are coldness, sweating, skin-color changes and swelling of the extremity. X-ray of the bones show spotty decalcification.

There has been an enormous confusion of terms for this syndrome. Terms referring to this syndrome are "post traumatic ascending neuralgia", "reflex sympathetic dystrophy", "causalgia", "minor causalgia", "post traumatic pain", "traumatic sciatica", "Sudecks atrophy". The pain may come on directly after injury and never abate, or it may commence weeks or even months

after the injury has occurred. In all thirty-one cases reviewed the condition was severe enough to require sympathectomy. The author could not find any typical chain of circumstances which produce reflex dystrophy. It is the author's belief that spontaneous lessening causalgic pain is the exception rather than the rule. The agonizing pain of causalgia fills the patient's entire life and consciousness and brings about serious personality changes. The local injection of procaine to block the sympathetic ganglia is the key to diagnosis and may also effect a cure. The general statement may be made that patients who obtain little or no relief from a block will obtain little or no relief from sympathectomy; the reverse is true to a lesser degree.

The results in this series were: good to excellent in twenty cases, fair in two cases and poor in nine cases. In every case the coldness, blueness and increased sweating were relieved by sympathectomy. Results in sympathectomy are better in younger age groups. The average time lapse between injury and sympathectomy was thirty-two months. Fifty-five percent of the females and seventy percent of the males had good to excellent results. It seemed that in cases of longer history of symptoms and well worn pathways, the patients did not respond so well as those whose symptoms were of shorter duration. The importance of active use of the extremity, as a valuable means of breaking the reflex, must not be forgotten. Furthermore, it must be emphasized that sympathectomy is not a cure-all for dystrophies. At present, sympathectomy is by far the best operative procedure for the treatment of reflex sympathetic dystrophy.

The underlying principle in prevention is to treat the trauma so that painless function of the extremity is restored in the quickest possible time. The author believes that the modern tendency to use procaine locally in the treatments of sprains is an excellent one, and that its use should be widened. Overtreatment of fractures is dangerous; splinting should not be continued too long and function of the extremity must be encouraged. Of this series, fractures and sprains were the inciting causes in one half of the cases. Surgery, such as orthopedic, of painful joints may be required, together with sympathectomy, to effect a cure.

Cullen (41) reports on a study of twenty-four patients in whom the major symptom was persistent pain after injury to one or more peripheral nerves. In a publication of the Medical Research Council (1920) the pain of causalgia was described as being: Spontaneous in onset; hot and burning in character; intense, diffuse, persistent, and subject to exacerbation; excited by stimulation which did not necessarily produce physical effect on the limb; usually aggravated by emotional excitement which brought on a paroxysm; and responsible for profound changes in the emotional state of the patient. Basing his opinion on this series of cases it is the authors belief that these descriptions appear to be much too rigid. Blocking the sympathetic ganglia with novocaine often gives valuable information despite the fact that the test is largely subjective. The technique of sympathetic block for upper and lower limb pain is described.

The objective findings encountered are glossy skin, spindle fingers, and clawed stained nails. Macerated skin and bullous lesions are sometimes encountered but may be related to reluctance to allow cleaning. Hyperhydrosis is not constant. Vascular dilatation is not always present. The limb temperature varied through coldness to normal to increased. Bone changes were not

specific. In regards to psychical assessment the author feels that too much attention has formerly been paid to personality changes. They are the result of pain. Once the pain is relieved they disappear. Every case of severe causalgia calls urgently for treatment, not only to relieve pain and suffering, but also to prevent crippling deformities, especially in the hand, which results from voluntary immobilization. In this series neurolysis was performed on nine occasions and in every case slight relief was obtained for a short period, (maximal period 3 weeks). Periarterial sympathectomy was done on five occasions without permanent benefit.

Of eleven cases treated by radio-therapy, four subsequently required sympathectomy. Of the other seven patients, six were convinced that improvement began two or three weeks after treatment and was progressive. The remaining patient was not improved and has since had a tractotomy. Three patients who obtained relief had brachial plexus traction lesions. This is a point of considerable importance, since in this group relief by sympathetic block is by no means the rule. Sympathectomy was performed on eight patients. Pain was completely relieved in seven. One patient continued with burning pain in the ring finger but the rest of the hand was free of pain. Twenty-three novocaine injections were performed in seventeen patients. Of these, eight later had sympathectomy and nine were treated by radio-therapy. No permanent relief from novocaine was observed. The patients who had no specific therapy showed, with a passage of time, varying degrees of improvement. While not altogether free of pain, they are not seriously incapacitated.

Olsen and Maycock (42) give a brief history of the studies on causalgia and report a case. The pain is usually a constant, persistent, deep burning pain, experienced exactly or roughly over the cutaneous distribution of a mixed or sensory peripheral nerve. One must beware of diagnosing these cases as psychoneurosis with hysterical hyperesthesia. The accepted approach to proper treatment is first to do a sympathetic block of the ganglia supplying the affected area. If partial or complete relief is afforded the diagnosis becomes established. Sympathetic ganglionectomy is then the treatment of choice. Overall results of repeated blocks do not justify the delay by this trial.

A case report of causalgia is presented. This patient received relief following novocaine blocks. This relief of pain lasted for six months and then a sympathectomy which gave permanent relief of causalgic pain was done.

White, Heroy and Goodman (43) describe thirteen cases of causalgia which were treated at a U. S. Naval Hospital. The history of causalgia is reviewed from the first descriptions by Mitchell, Moorehouse and Keen (31). Major causalgia with its typical triad of symptoms consisting of a disagreeable burning pain with hyperesthesia in the hand or foot, trophic changes, and autonomic stigmata of excessive vasomotor activity follows partial injury to the mixed peripheral nerves in penetrating wounds with a rate incidence at little less than 5%. Thermal and psychic stimuli which increase the sympathetic discharge from the hypothalamic centers aggravate the pain. It is admitted that the condition may improve without treatment, however, the process is so slow that the patient may become addicted to narcotics, suffer personality changes, or suffer serious crippling, irreparable damage to the bones, joints and soft tissue. The authors recommend preganglionic sympathectomy as an effective method of treatment and feel that it should be done

at an early date. In this study, repeated paravertebral chemical blocks have not been effective therapeutically but are recommended as a valuable diagnostic test. The results of sympathectomy on the thirteen cases presented showed complete relief in eight patients, the remaining five having some residual paresthesia and hyperesthesia severe enough in only one case to retard rehabilitation.

It is the authors' opinion that relief of the burning pain following sympathetic denervation is due to elimination of the efferent sympathetic discharge from the hypothalamic centers rather than to any interruption of pain fibers. They further state that they can find no evidence for the existence of centrally conducting sympathetic axones in the peripheral nerves. It is pointed out that the causalgic state is relieved under conditions which reduce sympathetic tone - quiet, warm environment, alcohol ingestion, sleep, and febrile states.

Doupe, Cullen, and Chance (37) ascribe causalgic pain to direct cross stimulation of sensory fibers by efferent sympathetic impulses at the point where the nerve trunk is injured. As further corroboration of this theory, Katz and Schmitt (45) have shown that under certain circumstances efferent nerve impulses can alter the excitability of adjacent sensory axones. Granit, Leksell and Skoglund (46) have given direct experimental proof of such cross stimulation. The authors feel that when a nerve trunk is involved in the causalgic state its sensory fibers may become so irritable that a similar "short circuiting" mechanism will be set up in the proximal neuroma after neurectomy at a higher level.

Turner (44) states that in the past few years there has been renewed interest in the syndromes of pain and dystrophy of the extremities first described by Mitchell, Paget, and Sudeck. The most important contributions to the basic physiologic fault have dealt with new concepts of transmission of nerve impulses in previously unrecognizable pathways. Some of these new concepts of the mechanism of pain in causalgia are discussed briefly with the admonition that further study of patients with such pain offers a fruitful field of collaboration among psychiatrists, internists, and surgeons.

The shoulder-hand syndrome is characterized by a unilateral painful disability of the shoulder associated with swelling, limitation of motion, and trophic changes in the hand and fingers. Steinbrocker, Spitzer and Friedman (47) present the results of 18 cases in a preliminary study with the following conclusions: Repeated stellate and upper dorsal sympathetic block seems to be the treatment of choice in the shoulder-hand syndrome. Complete recovery from the painful shoulder dysfunction occurred in almost all cases. Relief from pain and restoration of function was obtained by supplementary brachial plexus block in one case which had not been helped by sympathetic block. The vasomotor phenomena such as swelling of the hand were successfully treated with sympathetic blocks if done early. In long standing cases the contractures and trophic changes are usually irreversible although the associated pain and shoulder dysfunction are relieved even at the late stage. The cases which are a sequel to myocardial infarction proved to be the most resistant to treatment. Novocaine blocks to the sympathetic ganglia were administered at two to seven day intervals until recovery. Six to twelve blocks, or more, may be necessary to obtain relief. If the chemical block proves to be only temporary in its benefit, sympathetic surgery

has been advocated when the patients physical condition permits. Supplementary orthopedic, physical therapeutic and rehabilitative measures are desirable.

Miscellaneous Neuro-Muscular Conditions

Kovacs (48) states that physical therapeutic agents play an indispensable role in the diagnosis and treatment of many affections of the neuromuscular system. "Total rehabilitation" has broadened the field of physical medicine to include occupational therapy and reconditioning. Three types of neuromuscular disorders as they relate to physical medicine are discussed.

(1) **Peripheral Nerve Injuries:** Electrodiagnosis enables a differentiation between more serious lesions leading to a reaction of degeneration and minor injuries which recover spontaneously. Physical therapy must be employed early so that when the nerve regenerates there will be a mechanism capable of adequate movement. In the treatment of peripheral nerve injuries the aims are to improve circulation by heating, diminish wasting and fibrosis by electrical stimulation and maintain mobility of joints by active and passive exercise and massage. The details of treatment by means of the principal physical measures are presented.

(2) **Infantile Paralysis:** The early training of patients to use every available muscle fiber with the greatest possible efficiency is the crux of the newer treatment of poliomyelitis. The author discusses the uses of underwater exercises, electrical stimulation, moist heat, and graduated exercises.

(3) **Hemiplegia:** Physical therapy is necessary for early rehabilitation and reeducation of affected extremities, in hastening convalescence and contributing to mental ease. The methods of application of physical therapeutic agents - heat, massage, splinting, passive motion, - are discussed.

Pendse (49) discusses some of the problems of differential diagnosis of muscle weakness. Secondary muscle weakness usually occurs in convalescence from acute illnesses or as a result of metabolic derangement as in diabetes, or of infections as in tuberculosis, or of new growth as in cancer, or of many other systemic diseases.

Loss in muscle power may be due to many diseases of the nervous system. The wasting of muscles in this group is thus due to nerve tissue lesion and the involved muscles are those innervated by the affected nerve cells. This group of muscle diseases is termed myelotrophic. If it be a lower motor neuron involvement there is flaccidity of muscle. If the brunt of the disease is borne by the pyramidal fibers, there is the picture of upper motor neuron involvement - spasticity, exaggerated reflexes, loss of voluntary power, but no wasting.

In the group of muscle diseases known as myotrophic muscle disease it is presumed that something goes wrong with the normal nutrition of the muscle. The muscle starts wasting and loses its power. In some cases there may be outward hypertrophy aptly termed pseudohypertrophy. This group of myopathic diseases runs in families and usually occurs in males. The individuals usually

start showing symptoms at age of ten or twelve.

In myopathic or myelotrophic muscle disease the clinical picture is chiefly muscle weakness with absence of muscle tenderness. In peripheral neuritis, muscles are fairly tender. Sensory disturbances are most distressing in subacute combined degeneration and multiple neuritis. In acute myelitis and compression myelitis there are sensory disturbances and sphincters are generally involved. The diagnosis of muscle disease is greatly helped by the fact that the signs and symptoms that are present arise due to the involvement of the muscles themselves or the motor neurone. Myopathic and myelotrophic muscle diseases are usually symmetrical in involvement and the muscles are affected in groups. The muscle groups affected in myelotrophic and myopathic disease are different - the former is related to nerve supply while the latter is involvement of groups of muscles such as the shoulder muscle weakness in pseudohypertrophic paralysis. The spinal type sets in, in later life while the myopathic groups start at about age 10. The treatment of either type is very unsatisfactory.

Burrus (50) reports two cases of progressive muscular dystrophy in Negroes. The clinical and pathological aspects of the disease are discussed. As far as can be ascertained by the author these two cases represent only the fourth and fifth cases of progressive muscular dystrophy in Negroes reported in the literature.

Gilmore (51) reports briefly on three cases known to him in which there was unilateral quadriceps atrophy after having taken protamine zinc insulin over a prolonged period of time. One case had objective findings of atrophy but no apparent weakness noticed by the patient. Two cases had objective findings of unilateral quadriceps atrophy with inability to normally support the body weight except in hyperextension of the knee. No discussion or solution is offered.

Hansson (52) gives a follow-up study of 23 patients with recovery from paralysis of the serratus magnus muscle. The author discusses briefly the anatomy and comparative anatomy of the serratus magnus muscle with resultant deformities of the paralyzed muscle. As to the etiology, most cases were idiopathic, however, there was usually a history of exposure with a possible avitaminosis. Trauma, including post-operative and post-partum, is responsible for a considerable number of cases. Serratus magnus paralysis may also follow tetanus antitoxin injections and poliomyelitis. The deformity produced by such a paralysis is protrusion of the medial border of the scapula and a rotation of the scapula upward and laterally. Immobilization, therefore, should be by a support that presses the scapula to the thoracic wall and also derotates the scapula. Additional treatment includes electrical stimulation and specific exercises. The brace used presses the scapula against the thorax by means of a metal spring of semicircular shape, it goes over the shoulder to exert pressure anterior and posterior on the thorax. In addition there is a leather sleeve on the arm to prevent elevation of the arm. Illustrative pictures of the brace are presented,

Biochemical data has suggested that a state of a denervated muscle can be regarded as a "local hyperthyroidism". Two possibilities are suggested by Huff (53).

- (1) Thyroxin from the thyroid gland has a greater effect on denervated muscle.
- (2) The extra thyroidal production of thyroxin in the denervated muscle is different than that in normal muscle.

Experiments on rats showed that thyroxin accelerates, while thiourea inhibits atrophy. Acceleration of atrophy is also brought about by arsenic and dinitrophenol while retardation of atrophy occurs on a protein free diet.

A syndrome consisting of pain and flaccid paralysis about the shoulder girdle and upper arm is described by Parsonage and Turner (54). The clinical picture is that of sudden onset of pain about the shoulder which may radiate down the arm or into the neck. The pain may last about two weeks and then there is a flaccid paralysis of some of the muscles of the shoulder or arm. The important feature of onset is the absence of fever and constitutional symptoms. Clinically the pathological process can involve one or more peripheral nerves, two or more spinal roots, or the spinal cord. This condition appears to be a distinct clinical entity which became more common during the war years. No specific therapy for the condition is known. The treatment used has been similar to that used in poliomyelitis. The prognosis is much the same as anterior poliomyelitis with recovery continuing up to two years. The etiology of this disease remains obscure. A virus infection has been suggested as the cause. A similar syndrome may occur after serum injection and the two conditions may be identical. The name "Neuralgic amyotrophy" is suggested.

An unusual case of acute ascending paralysis occurring twice in the same individual with complete recovery from both episodes is reported by Weigner (55). The incomplete and unsatisfactory state of our knowledge regarding the whole problem of ascending paralysis is discussed in the light of the widely varying etiologies and pathological pictures reported in the literature. It is suggested that a disease entity characterized by a rapidly progressing and highly fatal paralysis does exist and that the term Landry's Paralysis or acute ascending paralysis should be properly reserved for this type only. It is further suggested that this type may be of viral origin and related to anterior poliomyelitis and infectious polyneuritis. Causes of other types of ascending paralysis are discussed and the fact that diagnosis and treatment of these other types constitute a problem for the internist as well as the neurologist is pointed out. The symptoms of acute ascending paralysis are described and differential diagnosis discussed. Appreciable danger of an erroneous diagnosis of hysteria during the early phase of the disease is emphasized.

Sanders (56) states that an aggressive few of the paraplegics may be given wheelchair, braces, and crutches and then need little coaxing to regain a place in society. Most of the paraplegics, however, feel inadequate, incompetent and dependent. It is necessary to help this latter group by stimulation, evaluation and training to rebuild the necessary muscular control and reestablish the functional mechanics of the body to the greatest degree.

It must be pointed out to the patient that life spent in a wheelchair is not only undesirable, but also detrimental to the maintenance of optimum health. Wheelchair exercises are necessary preparatory to exercises for getting to the floor; moving from wheelchair to another chair; learning to

manage braces; and participating in games and recreational activities. Mat exercises are beneficial in developing the muscle groups needed in ambulation. The ambulation instructor must participate in the total rehabilitation by carrying on the bladder training established by the urologist. In crutch walking, balance leverage and pendulum action are the tools with which we must work during the early period of ambulation instruction. We must schedule activities so that the patient's fears are dispelled in the knowledge that his braces support him.

Bed patients begin the rehabilitation by breathing exercises which bring into play the muscles of the shoulders and vertebral borders of the scapulae. Trapeze exercises in bed are employed to aid in changing positions and further develop the upper extremity. The author discusses the graduated exercises and patterns of motion which are employed from the stage of bed patient to the standing paraplegic patient.

Since the patient is likely to spend months in bed it is necessary that the instructor vary the exercises, altering dosage as the situation demands, since progress is often interrupted by intercurrent illness or operation.

When the paraplegic has been reconditioned by appropriate exercises, he is ready for the task of learning to put on his clothing and necessary braces. Much valuable exercise is obtained when braces, corsets, or other appliances have to be adjusted. The author states that his paper is to be continued with an analysis of wheelchair and mat class exercises so important in developing muscle tone and endurance which are essential for crutch walking.

Harvey, Tumulty, Bang and Leftwich (57) report on an epidemic in which typical pleurodynia and cervical myalgia appeared currently among the staff and patients of the Johns Hopkins Hospital during October and November 1947. Among the numerous synonyms for the disease are epidemic myalgia, epidemic pleurodynia, devils grip, Bornholm disease, epidemic phrenic neuralgia, and epidemic diaphragmatic spasm. It is an acute infectious disease, thought to be of virus etiology, which has appeared in epidemic form in many parts of the world. The diagnostic feature is paroxysmal pain in a muscle group or groups. Most commonly the pain is localized to the lower chest and epigastrium by coughing, sneezing, and breathing. The pain often radiates to the shoulders or neck, upper or lower abdomen, or back. Typically the pain is migratory and sometimes fleeting. Severe frontal headache is the most common associated symptom. Fever of 102-103 degrees is a common manifestation. Physical examination rarely discloses abnormalities, other than protective splinting. The infection runs its course in two to seven days, but may last up to three weeks. The occurrence of pleurodynia and cervical myalgia is often seen in the epidemic. The opinion is expressed that two clinical syndromes are not separate entities but variant forms of the same infectious process, the dominant manifestation of which is muscle pain.

Travell and Rinzler (58) give three illustrative case reports to demonstrate the striking resemblance which pain syndromes of the chest muscles may bear to effort angina and acute myocardial infarction. The cases presented are patients who demonstrate chest and arm pain and in whom no evidence of organic heart disease can be found, but in whom the diagnosis remains unsettled because the purely somatic pain syndromes which result from fatigue and strain of voluntary muscles are frequently overlooked.

This report deals with the differential diagnosis and treatment of pain syndromes of the chest which are primarily somatic in origin, but which resemble effort angina or acute myocardial infarction. In acute episodes of pain suggestive of myocardial infarction, the presence or absence of signs of tissue necrosis and circulatory collapse are of the utmost importance in weighing the diagnosis in one direction or the other. The absence of trigger areas tends to rule out skeletal muscle as a cause of the pain unless the involved muscle be located in the retro-sternal area. There is often "rheumatic tendency" of the patient with somatic muscle pain. In chronic effort syndromes of somatic cause there is an enormous variability in the exercise limit over a short period of time. Such variability is rarely seen in coronary artery disease. This intractable chest pain of somatic origin may be relieved by local block therapy (procaine infiltration or ethyl chloride spray) into the trigger areas. Relief of these pains in itself does not prove that the cause of the pain is primarily somatic, since under suitable conditions cardiac pain may likewise respond to local block of the appropriate somatic structures.

Denny-Brown (59) reports two cases of primary simple degeneration of the dorsal root ganglion cells associated with a primary degeneration of the muscles (Polymyositis). The co-existence of "myositis" was not suspected during life. A form of clinical polyneuritis that effects sensory function alone is sufficiently unusual to attract more than passing attention. Most forms of polyneuritis even though predominantly sensory do present some evidence of muscular weakness and wasting. Both cases presented a spreading numbness and sensory loss of the extremities, on one of the face, without pain but with severe and progressive ataxia. In both instances bronchogenic pulmonary carcinoma was present. The close similarity of the condition in the two patients suggests that the coincidence of carcinoma was more than chance association.

Detailed case histories and autopsy findings are presented along with several photomicrographs to illustrate the pathologic findings. In both instances the lumbo-sacral ganglia were the most heavily affected, but the disorder was widespread. The whole process of ganglionic degeneration presented the appearance of a primary atrophic process of nerve cells, without inflammation or vascular reaction. The anterior horn cells did not show any changes of the type shown in the dorsal root ganglion cells. The muscles showed a proliferation of sarcolemmal nuclei and increased cellularity of the connective tissue of a kind seen in chronic myositis, or rapidly progressive myopathy.

The type of degenerative neurons and muscular affection is entirely consistent with that resulting from metabolic disorder and present changes in man that are comparable to those associated with deficiency in pantothenic acid in swine. It is indeed possible that bronchogenic carcinoma produces a by-product which interferes with the biological conjugation of pantothenic acid in metabolism. Metabolic studies in similar cases in the future are indicated.

Repeated efforts have been made to integrate the divergent views on the etiology of multiple sclerosis, but we are still left a few seemingly contradictory approaches and opinions of the problem. Andren (60) presents

a brief survey of the pertinent facts elicited in the investigation of the etiologic factors in disseminated sclerosis with the view of correlating some of the more conflicting concepts. The vascular occlusion theory may be related to that of vasoconstriction or spasm. The vulnerability of the white matter, and possibly of the sympathetic nervous system as a whole, to noxious factors of metabolic, infectious, or other irritative characters is emphasized. The theory of local allergy as described by Ferraro and others, does not preclude the possibility of the above concepts, nor does the theory of virus etiology necessarily change the idea of the mechanism involved, although it is possible that the virus theory may hold only in limited cases.

The author emphasizes that a careful study of the history with investigation of the more minor symptoms, the nature of onset as well as remissions, may reveal additional etiologic factors that may become of preventive, therapeutic and prognostic significance. Careful laboratory studies made on cases of multiple sclerosis has revealed inconstant findings, suggesting possible multiple factors of etiology.

Spasmodic torticollis has been recognized for centuries and has failed to respond to many forms of treatment. Modern neuro-surgical techniques, however, have brought many successful results. Bunts (61) briefly reviews the clinical picture which is seen in spasmodic torticollis. Various theories of the causation of this disease are presented. Experiences with conservative therapy at the Cleveland Clinic have been generally unsatisfactory. The treatment recommended is division of the anterior roots of the first three cervical nerves on both sides. At a second stage operation after one week interval the spinal accessory nerve on the involved side is resected and ligated in the region of the sternomastoid muscle. Case reports with successful results following the above therapeutic regime are presented. Immobilization in plaster or fixation with bone graft have not been found necessary.

According to Kabat and Knott (62) the following principles are the basis for active exercise of patients with spastic paralysis:-

1. By repetitive use of the new pathway, improved function results, with increase in power and endurance and greater ease of performance.
2. Inactivity leads to loss of function and atrophy.
3. Voluntary motion performed by contraction of the agonist muscles results in reciprocal inhibition and relaxation of the antagonist.
4. Training of new patterns of motion is dependent on formation of new functional pathways in the central nervous system.
5. Successful repetition of a pattern of motion renders its performance less difficult requiring less concentration until the pattern becomes habitual and automatic.
6. The amount of activity in a muscle, motor nerve or central motor pathway depends primarily upon the percentage of the units being excited.

The greatest part of most reeducational programs of spastic paralysis is devoted to the teaching of sitting, standing, and walking by means of constant practice, rather than reeducation of individual muscles or groups of muscles, in single motion. Teaching a patient to sit or stand by having him do so is asking him to perform a complex combination of muscular contractions, when he cannot perform the simple motions of the combination, thus

resulting in failure. New principles in the treatment of spastic paralysis are as follows:-

1. Maximal activation of simple motions.
2. Re-inforcement of voluntary innervation.
3. In patients with a limit in range of motion, the emphasis is placed upon range and power of active motion.
4. Correction of muscle imbalance in antagonists.
5. Correction of substitution.
6. Correction of overflow.
7. Heavy resistance therapy to develop combination of two or more motions.
8. Training in habit patterns.

The principles listed above are discussed and the application of these principles is outlined by the authors.

Progressive muscle dystrophy is characterized by wasting muscles but no significant change in nitrogen excretion. Ames and Risley (63) investigated the distribution of nitrogenous products in the urine in such cases. It was found that there was marked increase in amino acid excretion in patients with progressive muscular dystrophy.

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SECTION 8

FRACTURES

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Fractures of the Upper Extremity

Fractures of the Clavicle - Ripstein (1) lists the following indications for open reduction and fixation of fractures of the clavicle: (1) oblique fractures of the middle third with marked displacement in which reduction cannot be maintained, (2) fractures of the outer third which present the same problem as acromio-clavicular dislocations, (3) any fracture in which a perfect cosmetic result is particularly desired, (4) cases in which immobilization of the arm would impose a severe economic handicap. The method of fixation favored by the author is an intramedullary wire procedure. Under general anesthesia with the patient on his back and a sand-bag beneath the scapula on the affected side, a one inch incision is made and the fracture exposed. A large Kirschner wire is then passed in retrograde fashion through the lateral fragment, through to the postero-lateral aspect of the shoulder and then drawn out until the medial end of the wire is flush with the medial end of the lateral fragment. The fracture is then reduced and the wire pushed across the fracture site into the medial fragment for approximately two inches. The projecting end of the wire is then cut off and allowed to lie subcutaneously. A sling is worn for 48 hours post-operatively after which full movement is allowed although strenuous exertion is discouraged. The wire is withdrawn under local anesthesia four weeks later.

Fractures of the scapula - Wright (2) presents a case of fracture of the coracoid process of the scapula with no tearing to the acromio-clavicular, trapezoid or coracoid ligaments. The injury was incurred in a football game when the patient was thrown into the air and landed on his left shoulder. The patient had no pain at rest, but was unable to move his left arm. Clinically the shoulder was somewhat elevated and the lateral end of the clavicle appeared to be situated on top of the acromium although there was no tenderness or pain to pressure at this point.

Fractures of the Humerus - Hammond and Clemmons (3) present a brief review of the literature on cases of fracture due to electric shock and present a case of bilateral humeral fracture due to this cause. Their case is that of a 56 year old woman who received a violent shock while holding one hand in a washing machine and the other on a water faucet. During the shock she shook considerably but received no direct trauma to the shoulders. Examination disclosed severely comminuted intra-articular fractures of both humeral

heads, the right shoulder showing fracture-dislocation with multiple fractures involving the surgical neck and humeral head. Closed reduction was performed on the right shoulder and both shoulders were abducted to 90 degrees with continuous traction suspension. The traction was continued for six weeks on the left arm and for eight weeks on the right, with uneventful convalescence. In the absence of any direct trauma to either shoulder it is plausible that the bone pathology was due to the combination of the effects of muscular contraction and of the passage of an electrical current through the bone.

Masland (4) describes again his reduction and fixation splints for non-operative treatment of fractures of the humerus and for fractures in and about the femoral neck. He states that the construction of the splints is based upon the principle of placing comfortable anchorages upon adjacent bones above and below the fractured member, metal strips being attached to these anchorages on both sides of the limb with sleeves that enclose the overlapping ends. In this way the necessary extension can be secured and then retained by clamping the sleeves.

Andreasen (5) reports a case of avulsion fracture of the lesser tuberosity of the humerus occurring in a 56 year old woman as a result of effort with the arm fully abducted above the shoulders, the hand being fixed and the body moving at the time. The patient incurred severe deltoid atrophy, contusion of the circumflex nerve with resultant neuropraxia, hemarthrosis and loss of internal rotation. After two months in an abduction splint and daily active exercises for the next two months she regained deltoid power, but never regained internal rotation at the scapulo-humeral joint. The avulsed fragment underwent aseptic necrosis and then was absorbed in twelve months.

Swenson (6) proposes a method of blind pinning of supracondylar fractures of the humerus in children where extensive swelling of the elbow prohibits immobilization in acute flexion after reduction. After reducing the fracture he inserts a wire through each condyle in an oblique fashion being directed posteriorly and inward to insure penetration of the shaft of the humerus. The wires are unequal in size to facilitate x-ray check of the position. After such fixation of the condyles, the wires are cut off even with the skin and the skin drawn over them. Sterile dressings and posterior splints with the elbow in 90-100 degrees flexion are applied. The wires eliminate the need for more acute flexion of the elbow and are removed under local anesthesia after three weeks. Care must be taken to avoid injury to the ulnar nerve.

McDonnell and Wilson (7) reviewed their cases of fractures of the lower end of the humerus in children. An excellent discussion of the anatomy of the elbow is presented, emphasizing that it is important to remember that the epiphyseal line separating the trochlea, capitellum and lateral condyle from the diaphysis runs transversely just above the lateral condyle cartilage and is within the synovial capsule. They point out that contrary to prevailing opinion, supracondylar fractures can produce serious growth disturbances if the fracture lines extend into the epiphyseal centers. Anterior-posterior displacement may result in permanent limitation of extension or flexion; lateral displacement may produce varus or valgus, although a functional result could still be good if no late nerve palsy develops. The authors found poor results in 50% of the cases of lateral condylar fractures treated

by closed reduction, thus pointing out the necessity for open reduction of these cases. They also noted that in spite of good reduction of a supra-condylar fracture, avascular necrosis of the trochlea may occur later, (although this apparently is very rare). Fractures of the medial epicondyle, unless the fragment enters the joint cavity, do not cause a serious disability.

Fractures of the Olecranon - Strug (8) reviewed the literature on anterior dislocation of the elbow finding a total of 34 reported cases, seven of which were accompanied by fracture of the olecranon, with his case making a total of 35. He discusses the mechanism and pathology of the condition noting that the majority have occurred as a result of a direct blow on the elbow although bizarre types of injury may cause the condition. External lacerations of the ligaments about the joint, injury to the muscles, possible separation of the muscles from their bony attachments and severe hemorrhage into the soft parts comprise the remainder of the pathology. Rupture of the brachial artery, tear of the brachial artery or arterial spasm comprise some of the possible vascular complications. If the radial pulse does not return on reduction one should suspect major vascular damage or massive hematoma calling for immediate operative intervention. In arterial spasm, upper thoracic and stellate sympathetic blocks may be beneficial. Unusually difficult reduction should lead to the suspicion of the distal end of the humerus "button-holing" through a lacerated triceps. The case reported was that of an 11 year old boy who struck his elbow against a tree in a fall from a bicycle. Here there was an anterior dislocation of the elbow joint with a fracture of the olecranon process remaining in normal relation to the humerus while the major forearm fragments were carried forward. Reduction was followed by the application of an anterior and posterior splint for three weeks. The author states that there was full return of function.

Michele (9) presents a method of wire fixation used in twelve cases of olecranon fractures treated during the past seven years. It is essentially a double loop method using a single continuous steel wire placed through a transverse drill hole in the distal fragment, thence through the site of attachment of the triceps tendon to the olecranon and then through a second more distal drill hole in the distal fragment. After anatomical reduction the ends of the wires are twisted and drawn tight and turned under the periosteum. Post-operatively passive motion is begun in two to three weeks with full motion before the sixth or seventh of treatment.

Fractures of the Radius - Hakala (10) presents a case of a 25 year old white male officer with a fracture of the head of the radius which appeared relatively innocuous radiographically and was to be treated conservatively until clinical examination showed complete loss of active supination, 50% loss of active pronation, moderate limitation of flexion and extension and severe pain on passive motion beyond these extremes. Consequently, an arthrotomy was performed through a postero-lateral incision at which time it was found that a piece of articular cartilage, $1\frac{1}{2} \times 1\frac{1}{2}$ cm. in size, had been separated from the lateral humeral condyle and was impacted edgewise into the fracture-line in the head of the radius thus accounting for the restriction of motion and severe pain. Hakala resected the head of the radius and trimmed the ragged edges of the cartilage defect in the lateral condyle of the humerus. In discussing the case and radial head fractures in general,

Hakala stresses the need to watch for possible myositis ossificans.

Fractures of the Ulna - Kitchen (11) presents a case of fatigue fracture of the ulna occurring in a 20 year old farm worker while he was shoveling manure. The patient complained of pain in the forearm, mostly at night. On examination there was a fusiform swelling of the middle third of the forearm with heat, tenderness and slight edema. X-ray showed a fracture of the ulna with considerable fusiform callus formation in the region of the fracture. In comparing this fracture with fatigue fractures of other bones, Kitchen notes the similarity of this case with fatigue fractures of the metatarsal bones and the dissimilarity with fatigue fractures of the long bones of the lower limb. The explanation may be that in the case of fractures of the metatarsal and of the ulna, the forces act at an angle of approximately 90 degrees to the long axis of the bone; whereas in the tibia, fibula and femur the stress is applied almost along the axis of the bone. This may be the reason for a clearly defined line of fracture in the metatarsal and ulna which is not seen in the tibia, fibula, and femur.

Fractures of the Radius and Ulna - Humphries (12) presents a case of a patient who sustained a severe open fracture of both bones of the forearm with displacement of the lower fragments, angulation and an inch of shortening. On admission, operation was performed, using an ivory peg to secure the ulna. On removing the plaster after six weeks the ivory peg broke and allowed movement at the ulnar fracture. The ivory peg in the ulna formed a sequestrum which had to be removed but eventual union occurred.

Trevor (13) presents a case of a 42 year old woman who caught her right forearm and hand in a machine. On examination she was found to have a skin wound completely encircling the forearm just above the wrist joint. There was comminution of the lower end of the radius, a fracture-dislocation of the lower end of the ulna, the proximal carpal joints were opened and all extensor tendons were severed. The median and ulnar nerves were intact. The radial nerve was severed at the wrist but the bulk of the flexor tendons were intact. At operation on the day of the injury the lower ends of the radius and ulna were brought together, dead muscle excised and sutured followed by application of plaster. The fracture was manipulated ten days later and remanipulated 28 days after injury. Seventy-seven days after injury free tendon grafts were taken from the tendon of the palmaris longus and inserted between the cut ends of the extensor tendons. At the same time one and one-half inches of the lower end of the ulna were excised. The patient returned to work approximately seven months after the injury but still required repair of the long extensor tendon of the thumb.

Miscellaneous - Stressing that Colles' fractures should not be too lightly regarded, Strange (14) points out that shortening of the radius, loss of the normal 15 degree tilt of the articular facing and varying amounts of separation of the ends of the radius and ulna may occur. Reduction consists of breaking up the impaction, restoring the normal radial articular facing and immobilization in a padded plaster from elbow to the metacarpophalangeal crease of the fingers. Moderate pressure is applied over the distal ends of the radius and ulna to closely approximate these bones. Facing and length is maintained by holding the hand in 60 degrees of flexion

and marked ulnar deviation at the radio-carpal joint. Immediate post-reduction films are stressed as well as repeated follow-up films with the critical period being between the seventh and tenth days when soft callus has begun to form. Immobilization is carried on for four to six weeks, after which the cast is bivalved and x-rays determine the future course of either physiotherapy or further immobilization. The possibility of Sudeck's atrophy characterized by persistent stiffness, swelling and circulatory impairment is pointed out. The author treats this condition by blocking the sympathetic ganglia or by the use of tetra-ethyl ammonium bromide. Some of the more common pitfalls are pointed out, such as mistaking a Smith fracture, (reverse Colles') for a Colles' fracture and displacement of the radial epiphysis in children.

White and Stevenson (15) proposed a method of treating forearm fractures by means of lateral traction exerted through the untapered cylindrical screw inserted in the desired fragment. They started using this method in compound fractures where they wished to avoid metallic fixation but they were so satisfied with the results they have been applying it electively also. Under novocaine or sodium pentothal anesthesia a stainless steel screw (with no tapering) is inserted into either the distal or the proximal fragment; whichever will elevate the other fragment when traction is applied. It can only be used where the fragments are in contact. After inserting the screw a padded long arm cast with a wire bow resembling a banjo splint is applied and traction gained by a rubber band between the wire bow and the screw. Traction is maintained until there is x-ray evidence of bony callus. Because of the limiting effect of the interosseous septum, overpull has presented no problem. It has not been found necessary to employ anesthesia in the removal of the screws.

Funsten (16) reviewed sixty-six cases of slipped radial epiphysis to determine end results and factors influencing them. Forty-eight were male and sixteen were female. The ages of the cases ranged from three and one-half years to eighteen years of age. The largest incidence was in the ten to fifteen age period. Follow-up was possible in only forty cases. The original displacement was complete (epiphysis more than half displaced) in forty-five cases and incomplete (epiphysis less than half displaced) in twenty-one. The reduction was complete (less than half a centimeter displacement) in forty-five cases and incomplete in twenty with no reduction attempted in one case. In the forty cases followed there were five with deformity. In three the deformity consisted of only slight shortening, the radial deviation was mild. In one case it was severe, and in another it was quite severe. The latter case was a compound injury. Funsten concludes that growth disturbances in epiphyseal injuries occurs less frequently than would be expected. Slight imperfections in reductions were not a calamity. He feels that attempts at reduction after twelve days following injury leads to greater deformity than non-interference.

Enyart, Brown and Trunnell (17) analyzed 52 cases of fracture of the carpal navicular bone. Recognizing that roentgenograms at the time of injury may fail to show a fracture of the navicular, they recommend that all patients giving a history of force having been applied to the palm of the dorsiflexed hand, and especially those with tenderness in the anatomical snuff box,

should be placed in a cast even though there is no evidence of fracture. Fluoroscopic examination of 17 of 23 cases in casts revealed very little motion of the navicular bone in skin-tight casts in contrast to appreciable motion in padded casts. They therefore recommend the use of skin-tight casts to prevent motion of the carpal navicular fragments during the healing period.

A general discussion of fractures of the navicular (carpal) is presented by Bonnin (18). The diagnosis of fracture of the navicular bone in the absence of x-rays may be suggested by a history of a fall on the wrist with subsequent pain in the region of the anatomical snuff box. The navicular is fractured in one of three ways: (1) by compression between the carpus and the lower end of the radius (2) by shearing strain due to excessive movement between the 1st and 2nd carpal rows, between which the navicular lies as a tie bar (3) by violent ulnar deviation of the wrist which avulses the navicular tuberosity (Sprain fracture). The varieties of fractures are grouped as (1) the common fissured, subcartilaginous fractures of the waist without displacement (2) the less common complete fracture with separation and displacement (3) fractures of the tuberosity of the navicular (4) fractures of the distal pole of the navicular (5) fractures of the proximal pole (i.e. proximal to the waist). The first type comprising 80% of navicular fractures does not require complete fixation of the thumb to gain union. The first metacarpo-phalangeal joint is therefore left free. Union is determined radiographically. Fractures of the navicular with displacement are associated with perilunar dislocation and form 15% of all cases. Bonnin has found the most successful position for fixation to be one of ulnar deviation obtained by "plastering the wrist under traction, with the thumb held so that it forms a straight line with the radial border" (the forearm and hand being pronated). The thumb as far as the metacarpo-phalangeal joint must be restricted. In fractures of the tuberosity of the navicular (sprain fractures) due to forced ulnar deviation of the hand, reduction is obtained by radial deviation and immobilized by "smaller plaster" (which extends to the metacarpo-phalangeal joint of the thumb). Fractures of the distal pole are treated in the same fashion as the subcartilaginous fractures. Fractures of the proximal pole should be treated by early excision of the small fragments inasmuch as the loose fragments inevitably undergo avascular necrosis. In the event of avascular necrosis, which is more likely as the fracture line approaches the proximal pole, the treatment is removal of the proximal pole as soon as the diagnosis of avascular necrosis is fully established. In the older cases with arthritis of the radio-navicular joint the author tries excision of the proximal pole first (excision of entire navicular if severe x-ray changes are present). If this is unsatisfactory, he removes the proximal carpal row and as a final confession of failure, fuses the wrist.

Dewar (19) reviewed the principles of treatment of fractures of the small bones of the hand, stressing early reduction, adequate fixation in position of function, avoidance of hand swelling, careful follow-up, care of the uninvolved portion of the extremity and early mobilization.

Jacobs (20) reports a case of fracture of the pisiform bone without other carpal injury. The rarity of this condition is indicated by noting that this brings the total of reported cases of this to 18. Jacobs claims

that the demonstration of the fracture depends on taking an 80 degree oblique view of the wrist with the joint in dorsal flexion. One must distinguish the fracture from anomalous bones, the secondary pisiform, the os triangulare and the separate styloid process of the ulna.

Anderson and Katz (21) present a brief review of the literature on fractures of the greater multangular bone and the opinions of different authors as to the mechanism of the production of such fractures ranging from indirect trauma to direct violence and as a result of a gunshot wound. The symptoms are chiefly swelling and pain on the radial side of the wrist and the base of the thumb and pain is aggravated by motion of the thumb. The diagnosis is confirmed by x-ray. They cite Greene and Miller as recommending treatment by immobilization of the thumb in slight abduction or an angle of 45 degrees to the carpal bones for a period of eight weeks. Except for possible limitations of apposition of the thumb the prognosis ordinarily is good. Two cases are reported of fracture of the greater multangular bone, one of which was caused by a gunshot wound and was accompanied by considerable soft tissue damage.

Goldberg (22) in 1946 described a new instrument for the treatment of metacarpal fractures based primarily on the principle advanced by Jahss. It relies on the flexed proximal phalanx to push upward on the distal fragment (largely head of the metacarpal) but it does not depend on anchorage of the metacarpal by the carpo-metacarpal joint capsule. The author describes the tendinous anatomy of the metacarpo-phalangeal joint to demonstrate how depression of the head of the metacarpal alters the directional pull of the lumbrical and the interosseous muscles thus extending the proximal phalanx and causing relative shortening of the flexor tendons. He discusses numerous methods in current usage for maintaining reduction of the fracture. The instrument consists of a radio-lucent plastic horizontal arm and a vertical arm of similar material. The horizontal arm is fixed to the forearm with plaster and on it is an adjustable pressure plate for pressure on the dorsal aspect of the proximal fragment. The vertical arm bolts to the horizontal arm and has an adjustable support bracket for putting pressure on the dorsal surfaces of the flexed second and third phalanges with 90 degrees flexion of the metacarpo-phalangeal joint. In case of a metacarpal fracture, after breaking up the impaction and reducing the fracture, the instrument as described above is applied maintaining the knuckle in its normal prominent position. It is advisable to include the next adjacent normal finger in the flexor fixation for a day or two to prevent rotation of the fragments. Goldberg removes the vertical arm once daily, holds the reduction manually and exercises the fingers. After three to five days when the swelling of the hand and spasm of the intrinsic muscles has subsided the vertical arm is replaced by a square which bolts to the horizontal arm and has a pressure plate which may be used to hold the head in normal position, allowing the fingers free motion.

Carlton (23) describes a case of a 35 year old porter who sustained an oblique fracture of the fourth metacarpal bone while lifting a parcel weighing thirty pounds into a rack of a railway compartment. There was no direct violence. The patient's blood phosphorus was double the normal and blood calcium half the normal. This was his first bony lesion.

Fractures of the Lower Extremity

Fractures About the Hip Joint - Freyberg and Levy, (24), discuss the general medical management of patients with fractures of the hip. They point out that except in rare instances when younger persons receive severe and unusual trauma such as would occur in automobile accidents and the like, persons who sustain a fracture of the hip are adults in the older age group. To determine the incidence and nature of the more common medical problems and complications encountered, they made an analysis of all cases of fracture of the hip treated at the hospital for Special Surgery during ten years, ending December 1946. Seventy-two per cent of the patients were women; the largest incidence occurred between 70 and 80 years. The average age of the women was 66 years, ten years older than the average men and three years older than the general average. Many were obese women in the post menopause period. Significant osteoporosis was frequent and is undoubtedly important in the etiology of the fracture. Significant complications occurred in 17 per cent of all cases. The average age of patients with complications was 71 years. The common pre-existing complications were obesity, diabetes mellitus, hypertensive vascular disease, and arteriosclerotic-heart disease. None of these illnesses appeared to endanger the patient or cause death, but made the management of the patient difficult when infection or vascular accident occurred. The most important complications were those acute illnesses which occurred after the fracture. These were chiefly pneumonia, decubitus ulcers, phlebothrombosis, pulmonary embolism. Most of the cases of pneumonia and pulmonary embolism occurred in patients confined to bed. The over-all mortality rate was 7.2 per cent. The average age of fatal cases was 74.5 years and 67 per cent of the deaths were in women. The authors believe that prevention of obesity would undoubtedly lower the incidence of fracture. They are of the opinion that weight reduction should be started in all obese patients at the outset of treatment for fracture. If osteoporosis is a prominent feature in post-climacteric patients, they recommend that the plan of treatment outlined by Reifenstein and Albright, using adequate amounts of estrogen and androgen in the form of diethylstilbestrol or testosterone. Prolonged rest in bed should be avoided whenever possible to slow down the further excretion of calcium and to prevent further aggravation of the osteoporosis. In their series, most fatalities were due to pneumonia - 50 per cent. Second most frequent post-fracture complication was phlebothrombosis which, in some cases, produced pulmonary embolism and infarction. The authors are of the opinion that anticoagulants (dicoumeral) should be used prophylactically during the first ten to fourteen days after the fracture of the hip, especially in bed patients, and certainly in all cases of pulmonary embolism to prevent extension of the phlebothrombosis and fatal embolism. They advocate protein hydrolysates and amino acid mixtures in those cases where protein supplements are needed; adequate vitamins to prevent or correct a deficiency state; special attention to prevent or correct failing heart should be given to patients with arteriosclerosis or hypertension; the administration of cathartics and sedatives should be confined to cases requiring them.

Johnson (25) gives a general review of experiences in treatment of forty-four patients with fractures about the hip joint. The author is aware that the follow-up in these cases is not sufficiently long to draw any concrete conclusion as to the efficacy of the plan of treatment outlined, but does believe that the end result can be fairly well indicated

in the majority of the cases during the first few months of the post-operative period. The danger of subjecting elderly patients, such as were found in his series, to surgical procedures, is well emphasized. The management of thirteen of the cases was outlined in detail. Smith-Petersen nails and Moore-Blount plates were used in the majority of cases. A Thompson nail was used in one case of transcervical fracture. In three of the cases outlined, all having transcervical fractures, two Smith-Petersen pins were used for internal fixation, "to give a mechanical hip". The author stated that double or triple fixation of hips has often been done, but that he has not seen a report of anyone using two Smith-Petersen pins. The use of two Smith-Petersen pins has given more satisfaction in his clinic than any other multiple fixation for transcervical fractures. Great stress is laid upon the necessity of reducing the operating time to a minimum, particularly in poor surgical risk patients.

Boyd and George (26) discuss the results following treatment of fractures of the hip. In a series of 360 fractures of the neck of the femur, the mortality was 7 per cent. The mortality varied from 0 in the sixth decade, to 42.9 per cent in the tenth decade. Bony union occurred in 84.7 per cent of the patients followed for one year or longer. In their experience, Pauwel's type 3 fracture did not show a predisposition to non-union, as compared to type 2. The incidence of aseptic necrosis was higher in patients with non-union, than in those with union, approximately 60 per cent in the former and 33 per cent in the latter. Approximately one-third of the cases with bony union, followed for two years or longer, developed severe arthritic changes. The authors believe that the development of methods for the treatment of severe arthritic changes following union assume even more importance than the treatment of non-union. They conclude that although the statistics on this type of fracture appear discouraging, internal fixation is the treatment of choice for acute fractures of the neck of the femur, because the mortality is lower, the patient is more comfortable, medical complications are less frequent, the percentage of senile psychosis is greatly reduced, the course of hospitalization is diminished, and the percentage of bony union is greater than with any other method.

Urist (27) has prepared three papers concerned with the analysis of 58 injuries of the hip joint which occurred in jeep accidents in World War II, in the European Theatre of Operations. The present paper deals with fractures of the acetabulum, without dislocation. The 16 cases of fracture of the acetabulum presented in this paper fall into the following classifications: (a) fractures of the rim of the acetabulum, 5 cases (b) central fracture, 8 cases (c) comminuted or bursting fractures disorganizing the entire joint cavity, 3 cases. In considering the traumatic lesion, certain anatomic considerations must be clearly understood. The weight bearing surface of the acetabulum consists of a lunate or horse-shoe-shaped platform of bone covered with articular cartilage. The anterior portion of the horse-shoe which is formed from the body of the pubis, is approximately half as wide as the superior portion. The anterior rim may be excised as in arthroplastic operations, without seriously altering the function of the joint, but the posterior rim is necessary for stability. The superior shelving portion is the thickest portion of the innominate bone, and is vital for the weight bearing function of the acetabulum. The status of

14 of the 16 patients in this group was followed. At the end of two years, 11 of the military patients followed had no serious disability. Many, however, complained of mild pain and clicking sensations in the joint, stiffness early in the morning, and discomfort from lifting heavy objects. Patients with displaced fractures of the supero-posterior rim of the acetabulum appeared to have more disability than those with anterior rim or central fracture. One patient with an unreduced fracture of the posterior rim had severe pain and some limitation of motion at the extremes of the normal range in all directions. One patient whose joint was accurately repaired at open operation, in contrast, had a normal hip. The three patients with extensive fractures of the acetabulum and destruction of the joint cavity, had ankylosis and complete disability two years after the injury. Fractures of the superior and posterior rims of the acetabulum of significant magnitude almost always resulted in some disability, but good function of the joint was obtained in one case after open reduction and accurate internal fixation. All evidence is to the effect that fractures of the pubic portion of the acetabulum are chiefly lesions of the anterior rim which is not essential to the function of the hip joint, while on the other hand, stellate or bursting fractures involve or distort the lunate, superior and posterior articular cartilage of the acetabulum which is necessary for normal weight bearing.

Intertrochanteric Fractures - Hammond and Cady (28) point out that since a large majority of the trochanteric fractures occur in patients over 60 years of age, it is only natural that serious associated diseases will greatly effect the prognosis in many cases. The occurrence of a serious femoral fracture with its attending shock, pain and complete disability in a patient already debilitated by advanced age and systemic disease is not infrequently sufficient to precipitate a fatal termination. However, efficient treatment of the fracture and prompt recognition and treatment of the associated diseases have resulted in a lower mortality in these cases. Close cooperation between the internist and the orthopedist should be productive of the best results. In recent years there has been an increasing number of trochanteric fractures treated by internal fixation, the advantages being early relief of pain, early mobilization and ambulation of the patient, decreased number of urinary, pulmonary and joint complications, and a lowering of the mortality rate. Sixty cases of trochanteric fractures are analyzed from a medical standpoint, referring particularly to the incidence, type and management of serious co-existing disease and the effect of such existing disease on morbidity and mortality. In the opinion of the authors, nothing is sacrificed by delaying operation until they start treatment towards the control of the co-existing disease, and this period of delay is time well spent as far as the patient's prognosis is concerned. The authors found that their patients did better if they received a blood transfusion during the operation. The fractures usually were fixed with a Smith-Petersen nail with a Thornton plate attached. After closure of the wound the patient was placed in bed without any external splint. After operation, the patient was allowed bed freedom and change of position every two hours, with gradual change to the wheelchair when the condition warranted. Crutch walking without weight bearing upon the involved extremity was allowed from two to three weeks after operation. Full weight bearing was not allowed until full union was demonstrated in the roentgenogram.

Cleveland, Bosworth and Thompson (29) wrote on the management of the trochanteric fracture of the femur, describing the type of injury producing the fracture, outlining the factors modifying the mode of treatment, describing the modes of treatment, and comparing the results of internal fixation and traction. Patients with this fracture are an elderly group. Their average age is about 75 years, placing their age more than 12 years above that of the average of patients with intra-capsular fractures of the neck of the femur. Ninety per cent of the patients were women, a fact probably explained by the less rugged bony structures and usually more pronounced atrophic osseous changes in women. The injury is generally trivial and the authors believe that most fractures of the type occur by dissolution of continuity of bony structures preceding the fall, and are not a result of the fall. They pointed out that perhaps the main contributing factor in such injuries lies in the elderly person's inherent instability while erect and her slow reflex response. The authors state that trochanteric fractures may be roughly divided into three main classes, depending on the location of the major point of bony injury, namely paratrochanteric, intertrochanteric, and subtrochanteric. They emphasize that the treatment of these fractures is not easy, and point out that the paratrochanteric fracture will tend to result in a final external rotation deformity, the subtrochanteric fracture will tend to be difficult to control and finally may result in rotation deformity, shortening and angulation. In outlining the mode of treatment the authors discuss Buck's extension, Russell balanced traction and the Whitman plaster spica. They do not favor the use of the latter, as a rule. With the gradual development of a method of attachment of a plate to the Smith-Petersen flange nail, internal fixation of trochanteric fractures has become the treatment of choice provided the necessary equipment and a trained surgeon are available. Traction of the types previously mentioned are suitable under circumstances where transportation is impossible and physical help unobtainable. The authors base their conclusion from a study of a series of 133 cases. One group of 38 patients treated by traction was compared with a second group of 95 patients treated by internal fixation. The final result was accurately known in the latter group. The study covered an eight and one-half year period. The great bulk of the fractures were paratrochanteric and generally comminuted (80%). The rest were subtrochanteric, paratrochanteric and the combination of the foregoing. Decision to attempt internal fixation as the method replacing balanced traction was made on a review of the records of the traction patients. A great many unsuspected complications appeared on their follow-up. Despite excellent nursing care, pressure sores on the sacrum and buttocks were the rule rather than the exception. Cystitis, bladder complications, residual stiff knees, hip contractures, permanent vascular changes, peroneal nerve palsies, muscle atrophy, senile psychoses, prolonged general inanition and debility and a high mortality were disclosed. The three flange nail with plate affixed with nut or bolt was found to lack stability at junction of the nail and plate, and after a trial was discarded. The Jewett nail was finally used with a few minor structural changes. Where nailing is properly done, no coxa vara or external rotation deformity will develop unless the nail breaks or pulls out of the bone. The nail most frequently used is angled at 130 degrees and is about three inches in length. After operation patients are replaced temporarily in traction pending application of a Thomas brace with pelvic band and knee lock. Continuance of such brace

until solid union is obtained, is essential. Full weight bearing with the brace is neither necessary nor advisable. Such ambulation with minimal weight bearing can rapidly be permitted. Union rarely occurs before three months and sometimes is not complete up until seven months. The authors urge that early mobilization of the patient is admirable, but early full weight bearing may prove disastrous. There have been complications from this method of treatment, but far less frequent and much less devastating than those found in the conservatively treated group. In the conservative traction treatment group there was a mortality of 36%, while in the cases in which nailing was done there was a hospital mortality of only 12.6%. Eleven per cent of the patients treated by balanced traction developed senile psychoses and they were transferred permanently to mental institutions. Of patients treated by internal fixation, only 2.1% experienced similar psychoses. As regards survival, 32% of patients treated by traction survived one year from the date of the fracture, while of those treated by internal fixation 72% survived a year. By the end of the second year only 29% of the traction treated patients were alive, with 38% of those treated by internal fixation survived. At the end of four years, only 13% of the conservatively treated patients were alive, while 30% of those in whom nailing was done survived. In considering the time patients spent in the hospital, it was found that traction patients remained an average of 14 weeks while those with internal fixation stayed but 8 weeks. The authors now operate on and nail all intertrochanteric fractures because they have found that the patients survive despite adverse pre-operative opinion.

Wahl (30) discusses the types of treatment which have been employed for intertrochanteric fractures and gives four case histories of patients in the age group of 80-89 years, treated by internal fixation with a Moore-Blade plate. He is of the opinion that the appliances which have been developed for use in fractures of the neck are not suitable for treatment of intertrochanteric fractures except those recently developed by Neufeld, Jewett and Moore. He considers these superior because they pass through the fracture line and anchor to the shaft of the femur with screws. He guards against the assumption that treatment of the intertrochanteric fracture is much easier than that of the neck, emphasizing that intertrochanteric fractures produce more pain and shock than produced by fractures of the neck of the femur, on account of the frequency of severe bleeding following tear of the surrounding soft tissues. He concludes that the handling of these fractures in the aged is much more difficult than fracture of the neck of the femur. He points out that the problems of treatment are union without coxa vara, correction of the shortening and external rotation of the limb, avoidance of bed sores, pneumonia and thrombosis. He allows his patients out of bed one or two days after the operation and early ambulation with crutches in appropriate cases.

Hammond (31) has presented a review of 45 patients with 46 trochanteric fractures of the femur which he has treated by internal fixation. Like other authors he has come to the conclusion that internal fixation of trochanteric fractures is the method of choice, because of the advantages gained in providing early ambulation to these elderly patients.

Fractures of the Neck of the Femur - Van Gorder (32) presents an excellent discussion of cases of acute fractures of the neck of the femur. In the substance of the article are included paragraphs on the selection of patients for operation, the proper time for operating, the type of anesthesia, technique of reduction, technique of operation, post-operative care, and the prognosis. In summarizing the article the author reaches the following conclusions: (1) that age is no contra-indication to operation; (2) that the optimum time for operation is within one week of the injury, and the earlier the better, all things being equal; (3) that accurate reduction of the fracture is of paramount importance, since the more accurate it is, the better the chances of union; the poorer the reduction the greater the chances of non-union; (4) that skeletal traction or a traction table is not necessary to reduce the fractures of the neck of the femur or to maintain the reduction while they are being nailed; (5) that after manipulation and reduction of the fracture with the patient under anesthesia, manual holding of the fractured leg by an assistant is adequate; (6) that the most difficult fracture of the femoral neck to reduce and treat successfully is the sub-capital vertical type; this being so, treatment by nailing should be supplemented by bone grafting, or else some form of osteotomy should be performed; (7) that fixation material (nails, screws, pins, etc.) should be made of metals that produce no ionization in the tissues; (8) that arthrotomy is not necessary for nailing of the majority of fractures of the femur; (9) that the operation can be performed with little trauma or shock; (10) that the proper position for the Smith-Petersen nail is along the lower half of the femoral neck, its sharp end centering in the proximal portion of the head of the femur in both antero-posterior and lateral planes; (11) that the lateral roentgenogram is indispensable in determining the reduction of the fracture and the placement of the nail; (12) that it is rarely necessary to drive the guide wires across the joint line into the acetabulum in order to control location of the femoral head while nailing; (13) that if complex multiple wires or pins are used for internal fixation of the fracture some form of retention apparatus such as a nut inserted on the ends of the wires must be employed in order to prevent them from wandering out of their position; (14) that patients can be gotten out of bed on the day of operation or the day following, but that this procedure is not necessary as a rule, is often ill advised and should be employed only in exceptional instances; (15) that the prognosis of fractures of the neck of the femur depends to a large extent on their location, their obliquity, and the adequacy of nursing care received; (16) that according to the most reliable reports and literature, internal fixation methods of treating fractures of the neck of the femur result in a higher percentage of bony union and a much lower mortality than do methods involving external splinting and traction.

Fitzgerald (33) discusses two anatomical features which may lead to non-union in cases of fracture of the neck of the femur. The first is that the tendon of the obturator externus muscle which lies very close to the femoral neck and actually grooves its under surface, might slip in between the bone ends either at the time of fracture with the lower fragment moved upward, or during the usual Leadbetter method of reduction when the hip is forcibly internally rotated and abducted. In addition, he points out that when the femur is forcibly internally rotated in an effort to reduce the fracture, a wide transverse gap develops on the posterior surface of the neck. A nail inserted after forced internal rotation, therefore,

would have a grip in the outer fragment and in the head of the bone, but would be uncovered posteriorly while traversing this area. After having found that a very large number of cases had failed to unite when operated upon after forced internal rotation, the author decided to accept some external rotation deformity and has found that the percentage of success has been much higher. In discussing the types of fractures and their treatment, the author divides the cases into the impacted and the non-impacted fractures. He further divides the former into coxa valga with impaction and coxa vara with impaction. In the cases of coxa valga with impaction the author immobilizes the hip in a closely fitting plaster spica and allows it to remain for two months, the patient being allowed to walk after a few days. In the cases of coxa vara with impaction which he manages conservatively, the patient is kept in bed on a Braun splint with 10 pounds traction for three months and is then allowed to get up. In the impacted cases operated upon, the nailing is done without any attempt at reduction of any kind. For the treatment of non-impacted fractures, the author describes in detail two operative procedures, nailing and a modified form of Leadbetter's osteotomy.

Waspé (34) reports a case of sub-capital fracture of the neck of the femur. The patient was first seen in November 1947 with a swelling on the medial side of the upper part of the thigh following a blow in the region of the right hip. The patient stated that he had received an injury in this situation in 1941. During the discussion it was agreed that this was an old abduction transcervical fracture of the neck of the femur, the type which usually unites in spite of lack of immobilization.

Martin (35) reviews 74 cases of fractures of the hip treated in the previous two years. The Moore plate was used for intertrochanteric fractures and the Smith-Petersen nail or Godoy-Moreira screw for high fractures. The screws gave excellent fixation, but there was difficulty in engaging the large thread with the hard bone near the acetabular surface. Many failures with the Smith-Petersen nail were due to insufficient engagement of the head. Direct fluoroscopy was employed.

Caniza (36) is of the opinion that many anatomic fractures which are classified as impacted are really not impactions but rather an overlapping of portions of the neck due to the displacement of the two fragments. He states that this can easily be verified by taking another X-ray with the limb in the abducted position. In his opinion, a real impaction is a partial sub-capital fracture in which the head is depressed somewhat backward as in epiphyseal fractures. Caniza prefers the cannulated Smith-Petersen nail which is threaded on a Kirschner wire and driven home. He points out, however that the operation should not be taken lightly by the uninitiated.

George (37) reviewed 300 cases of central fracture of the neck of the femur treated at the Campbell Clinic. Only type 2 and type 3 fractures according to the classification of Pauwel, are included in the study. Of the group of 300 cases, 252 were type 2 fracture (84%) and 48 were type 3 fractures (16%). Seventy-eight per cent of the patients were 60 years of age and over. Eighty-two per cent of the patients were women and 18% were men. The author explains the striking difference between the incidence

of the two sexes by assuming that since elderly men lead a more active life than elderly women, there is not as much osteoporosis of the bones of the men. He also explained that the preponderance of women may also be due to their wider pelvis, with a resulting genu valgum. The overall mortality rate was 9.3%. Of the 300 cases reviewed, only 47% had adequate follow-up for over one year. Concerning the 47% (141 cases), bony union occurred in 86½% and non-union in 13½%. Ninety-three and three tenths per cent of the 45 cases under 60 years developed bony union. There were no non-unions of the 11 cases under 40 years of age. In the 96 cases over 60 years of age, the percentage of union was 83.3%. There were 10.3% non-unions in type 3 fractures, and 14% in type 2 fractures. In reviewing these cases the impression was gained that accurate reduction and adequate nailing of the fracture fragments influences union. As regards aseptic necrosis, it is found that in the group of 122 unions there were 41 cases (33%) which showed aseptic necrosis at some time during the follow-up. No relationship between age and aseptic necrosis was found. In 19 cases it was discernible in 9-15 months, in 11 cases in 15-27 months, and in 11 cases after 27 months. On this basis it was concluded that the greatest number of cases begin to show changes in the head in about one year, and the length of time up to two and one-half years gives no assurance that aseptic necrosis will not develop. In the non-unions, approximately 60% of the cases showed aseptic necrosis of the femoral head. Nineteen per cent of the hips (23) showed moderate arthritic changes in the head, and 14.6% (18) showed severe arthritic changes. The time of appearance of arthritic changes seems to follow a time of appearance of aseptic necrosis from several months to a year. The author concludes that even though the statistics present a rather dreary outlook for internal fixation this method is much superior to the Whitman abduction method. As to optimal time for operation, the author believes that it is highly advantageous to the patient to operate within the first 48 hours.

Neer and McLaughlin (38) furnish a follow-up report of 130 patients treated with internal fixation with a Smith-Petersen nail. The cases are segregated into three categories according to the classification described by Pauwel, type 1, valgus; type 2 mid-neck; type 3, oblique sub-capital. In the group there were 26 valgus with average age of 59, 57 mid-neck with average age of 66, 47 sub-capital with average age of 66. As regards the management, every hip fracture was considered an acute emergency demanding early treatment designed to minimize the period of pain and bed stay. Eighty per cent of the patients were operated upon within 6 hours of admission. Impacted valgus lesions were nailed without reduction or visualization of fracture. All displaced fractures were reduced prior to fixation. Sub-capital oblique fractures were the most difficult to reduce and frequently could not be reduced adequately with manipulation alone. Following operation 65% of all patients were allowed out of bed within 24 hours. Those physically able to use crutches commenced ambulation without weight bearing in a walker about the fourth post-operative day, and were promoted to crutches as rapidly as possible. The mortality in this series is outlined as follows: operative 2%, related 2%, unrelated 8%. The results in each type of fracture are discussed in detail. The over-all results are tabulated as follows:- total mortality 10.7%, non-union 21.9%, aseptic necrosis 42%, in the open cases. In the closed, the mortality was 9.7%,

non-union 16.1% and aseptic necrosis 54%. The authors conclude (1) that the best time for reduction and fixation of the hip fracture is immediately (2) good treatment for impacted valgus fractures of the femoral neck is internal fixation and avoidance of bed stay (3) open reduction, properly done, is surer, shorter, but more dangerous than closed reduction and blind nailing (4) open reduction does not increase the incidence of subsequent aseptic necrosis.

Ellis (39) and his co-authors discuss their experiences and results obtained in treatment of 30 cases of fractures of the neck of the femur and the trochanteric region. They believe that internal fixation of fractures of the femoral neck, using the closed method of treatment is the one of choice.

Gallagher (40) presents a review of 77 consecutive fresh fractures of the neck of the femur treated at Jackson clinic during the years 1936-1946 inclusive. In this series, 17% were under 60 years of age, 23% between 60-70 years, 59% between 70-90 years and one over 90 years. Eighty-eight per cent were females, twelve per cent were males. Thirty per cent of the patients had impacted fractures and all made uneventful recoveries except one who submitted to internal fixation and subsequently developed absorption at the fracture site and aseptic necrosis of the head. There were 3 deaths in this group from 2-9 years following injury. Treatment of those with impaction was conservative, consisting of bed rest, traction with from 4-5 pounds for one month to six weeks and then a wheelchair and partial weight bearing with crutches. Full weight bearing was permitted at 3-6 months. No disrupted impactions or other complications developed during the hospitalization, largely due to the excellent nursing care. Of the 55 displaced fractures of the neck, sub-capital, transcervical and basal, 52 were treated with internal fixation with a Smith-Petersen 3 flange nail under spinal anesthesia. The over all mortality in the displaced group numbered 22, or 40%. The deaths occurred anywhere from 3 months to 9 years postoperatively. The principles generally adhered to were (1) antero-posterior and lateral x-ray examination on admission, (2) immediate traction, (3) evaluation of physical condition with supportive therapy, (4) accurate reduction using modified Leadbetter technique, (5) lateral nailing with Smith-Petersen nail, (6) impaction, (7) leg traction for one week, (8) early ambulation and discharge from the hospital in three weeks using crutches, (9) discard crutches at three months, (10) follow-up x-rays at 3-4 month intervals for 2 years. In this group there were 6 non-unions or 11.5%; 28, or 53.8% showed aseptic necrosis; and 35, or 67.3% of these patients had degenerative arthritic changes of various degrees characterized on x-ray by lippling, diminution of joint space, coarseness of trabeculation, thinning and eburnation of the articular cortices. The nails were removed in 18 cases at various intervals after one year after aseptic necrosis had occurred; in 10 cases the nail was loose and partially extruded and the cannulated portions filled with necrotic debris on microscopic examination. The author concludes that the incidence of aseptic necrosis and degenerative arthritic changes is alarmingly high in this series. He attributes these complications to (1) too early weight bearing and (2) internal fixation by lateral nailing adds a certain amount of damage to the already acutely impaired circulation.

He believes that the Smith-Petersen nail has stood the test of time. Perhaps with the addition of a cancellous bone graft or some other means of promoting osteogenesis, and delay in full weight bearing for a year or so, a more satisfactory program will be established.

Fractures of the Shaft of the Femur

Wiltberger, Mitchell, and Hedrick (41) discuss fracture of the femoral shaft complicated by hip dislocation and report a case successfully reduced by the closed method. The authors emphasize the rarity of the condition and state that over a period of 31 years at the Henry Ford Hospital, only four cases have been seen in a total of 496,000 patients. This would average about one case in 125,000. In the case being reported, the patient was a white male 35 years old who was struck from behind while kneeling by a large girder which had slipped from an overhead crane. Roentgenogram had disclosed an oblique fracture of the upper third of the right femur and a complete posterior dislocation of the hip joint. An unsuccessful attempt at closed reduction of the dislocated hip was made with the Bigelow and Ellis procedure. Thereafter a reduction-retention apparatus with threaded pins was used, with the pins placed approximately four inches apart into the lateral aspect of the trochanter of the left femur. After two additional unsuccessful attempts were made at reduction, a two foot length of gas pipe was threaded across the bar of the reduction apparatus, paralleling the distal fragment and being attached by the apparatus to the proximal fragment. With the gas pipe lever a successful reduction was carried out by means of the Bigelow maneuver. The patient was then returned to the ward where he was placed in skeletal traction. Roentgenograms taken the next day showed the head of the femur to be in the acetabulum and the fracture to be in almost anatomical position and excellent alignment. Six months later it was found, after testing the patient clinically and taking roentgenograms, that he had non-union at the fracture site and that the proximal fracture of the femur cast a shadow of increased density. The authors believe the latter condition to be excessive stripping of the periosteum at the time that the dislocation took place. An open reduction was performed and a vitallium plate and massive onlay bone graft from the tibia was placed across the fracture site. The post-operative course was uneventful and the fracture healed, three months later.

Humphries (42) discusses the general subject of fractures of the femur, based on his experiences in the treatment of 33 consecutive cases; 32 fractures of the shaft and one of the neck. In discussing the treatment of trochanteric fractures, the author states that whenever possible the fracture should be nailed, and the nail introduced at a much lower level and in a more vertical direction than for a transcervical fracture. If the fracture is comminuted, leg traction is preferred to nailing. In the treatment of abduction transcervical fractures, impaction of the fragments is not interfered with. The limb is immobilized in a short spica plaster cast which includes the pelvis and extends to just above the knee on the affected side, with the limb in a position of extension, slight abduction, and no rotation. Internal fixation with the Smith-Petersen nail is preferred in the abduction transcervical fractures. Osteotomy is believed to be indicated in the treatment of ununited fractures of the neck in which it is not worthwhile attempting repair of the fracture owing to destruction of the blood supply of the head, arthritis of the hip joint, deformity of the joint or shortening of the neck.

Stuck and Grebe (43) report on a survey of 124 consecutive fractures of the shaft of the femur observed over a period of 15 months in an Army hospital. In this group of 124 fractures, 25 were in the upper third, 84 in the middle third, and 15 in the lower third. Only 28 of these patients received their entire treatment at the hospital where the authors worked. Eighty-four patients received their fractures from automobile or other vehicle accidents, 19 were due to explosions or to the effects of high velocity missiles, and 13 fractures were due to falls from a height, including a parachute jump. The remainder were due to miscellaneous causes, airplane crashes, blows from an airplane propeller or pathological fractures. Eighty-six were simple fractures, and 38 were compound. Thirty-two patients, or more than one quarter of the series, suffered serious complicating injuries. As regards the treatment, some form of skeletal traction was used in 91 cases. In 20 cases a Kirschner wire or Steinmann pin was placed in the lower end of the femur above the knee, and in 71 cases the wire or pin was placed through the upper end of the tibia. No ill effects were observed from traction in the upper end of the tibia, and the conclusion is drawn that traction through the upper end of the tibia does not endanger knee motion as much as a pin through the lower end of the femur which may produce adhesions of the capsule of the knee joint. Eighty operations were performed and screws were used in 33 cases, bone grafts and screws in 16 cases, plates and grafts combined in 30 cases, and screws alone in 1. Sometimes several different operative methods of treatment were combined in one case. The principal complications were; failure to reduce fracture with traction - 35 cases; refracture or secondary fracture - 21 cases; delayed or limited union - 13 cases; non-union of fracture - 12 cases; limitation of knee motion - 12 cases; mal-union of fracture - 11 cases; infection due to injury - 10 cases; infection from open operation - 8 cases; shortening 1" or more - 7 cases; non-union of fracture after open reduction - 6 cases; renal calculi - 3 cases; thrombophlebitis - 1 case; delayed union or limited union was the most frequent complication encountered. The authors believe that an earlier reinforcement bone graft hastens recovery and prevented secondary refractures. Ununited fractures of the shaft of the femur were treated with multiple iliac bone grafts.

Fractures of the Patella: - Coleman (44) adds two case reports of recurrent osteochondral fractures of the patella to the literature. This author states the fracture occurs in two frontal sections with an articular portion shearing off and remaining displaced while the anterior portion reduces itself. He states the mechanism of injury is produced by the patella sliding laterally over the lateral femoral condyle, and in so doing scoring the articular surface of the patella and condyle. The medial border of the dislocated patella is caught by the edge of the lateral condyle when the quadriceps contracts, causing considerable tangential force which is applied, shearing off a portion of the articular cartilage of the patella usually with a thin layer of underlying bone. He feels that these fractures should be recognized early, loose bodies removed, the defects in the articular surfaces smoothed off, or the patella removed if intensively involved. He states plication of the capsule on the medial side is recommended in order to prevent recurrence of the injury.

Michele and Krueger (45) report a method of wiring used in 32 of 247 cases of fresh fractures of the patella over a five year period from 1942 - 1947. The election of wiring cases had one pre-requisite in their study, namely the main fragment had to show one inch or more separation. Excellent diagrams are included to show in detail the method of wiring. They stated that the results of this method of treatment reveal (1) smooth and sturdy closure of the fracture, (2) reduction of complications following such fractures, as well as greater ranges of motion when some limitation of motion was present, (3) marked reduction of the number of days hospitalized as well as of convalescent days, early ambulation and nursing care and (4) the final healed patella more nearly simulated a normal patella than following other methods.

Fractures of the Tibia: - Loomis (46) reports a series of 20 cases of open reduction of oblique or spiral fractures of the tibia with insertion of one or more vitallium screws across the fracture site which in his hands is a simple method of restoring length and minimizing delayed union by hairline reduction. He states that this type of fracture is accompanied by (1) shortening due to forces or muscle pull upon the fracture and (2) delayed union caused by poor blood supply to the distal fragment especially in the distal third of the tibia. He outlines recognized surgical and orthopaedic principles and in addition recommends application of the head of the screw on the medial side of the tibia for easy removal at a later date, a high leg cast after operation, and a Steinmann pin through the upper tibia incorporated in the cast in obese patients to reduce rotation strain. He feels that hairline reduction may be misinterpreted as union, encouraging premature cast removal and too early weight bearing.

May (47) explains in anatomical detail the cause of the high incidence of non-union in double fractures of the shaft of the tibia. He states that it is caused by disturbance of the interosseous circulation following such fractures, and particularly in double fractures with a segment deprived of its blood supply because of the few anastomoses unless the segment contains the nutrient vessels. He feels in segmental fractures the best treatment is complete and prolonged immobilization of the limb in a skin tight plaster cast to permit ingrowth of vessels from the peripheral fragments, and states if non-union does occur the best treatment is by bone graft, long enough to bridge both fracture sites. In order to avoid weakening the other leg by taking a long massive graft from the tibia, this author advises the use of a fibular graft from the same side. He prefers transfer of the fibula to the tibia in stages, and recommends fusion of the upper tibio-fibular joint in the first stage and osteotomy of the lower part of the fibula and fusion of this part to the tibia in a second stage. By this method he feels that the fibula does not become separated from its blood supply.

Dislocation of the Head of the Fibula: - Vitt (48) reports four cases of anterior dislocation of the head of the fibula from parachute landing falls. He states that the condition occurs in a twisting lateral fall at the time of striking the ground, and is associated with inversion ankle strain. He feels it is related to the relaxation of the fibular collateral ligament and the tendon of the biceps femoris,

because paratroopers are taught to land with the knees flexed and together. He states that the symptoms are a feeling of the knee being "out of joint", limitation of extension from 170-160 degrees and 10-20 degrees limitation of flexion. In his series there was no sign of peroneal nerve involvement. He reduces the dislocation under pentothal by inverting the ankle, flexing the knee and direct posterior pressure over the head.

Fracture of the Fibula: - Burrows (49) reports five cases of fatigue fractures of the fibula together with a review of the literature on this subject. He feels that the stress of muscular action is emphasized by fracture of the fibula, a non-weight bearing bone, and in his series there is no predominance of the site, age, sex, or occupation. He calls attention to the predominance of two groups of patients in whom this condition may occur (1) young male runners or skaters and (2) women of middle age or over who have much to do on their feet. He feels that freedom of movement, in spite of tenderness, helps to distinguish this group from sprain, and re-emphasizes that in early suspected cases films should be repeated in three weeks, for x-rays at time of the first signs and symptoms may be negative, with a fracture line appearing after rarefaction at the end of the second or third week. He treats this condition with an elastic adhesive bandage from the metatarsal heads to the upper calf, and notices the pain diminishes or disappears within a week although tenderness may remain as long as 8-16 weeks.

Fractures of the Ankle: - Lange (50) presents an analytic historical survey of ankle fractures completely covering the subject from Hippocrates to modern times, and concludes: (1) the exact genesis of most fractures of the ankle is still unknown, (2) the problem of relationship between the marginal tibial fractures and the malleolar fractures, and between the former and rupture or detachment of the syndesmotic ligaments has not been solved, (3) a sure knowledge of rupture or detachment of the ligaments of the syndesmosis and various types of ankle fractures has not been reached, (4) the criteria of rupture or detachment of syndesmotic ligaments are uncertain, (5) the classification of malleolar fractures is almost chaotic and, (6) no attempts have been made to reduce malleolar fractures in conformity with their actual nature.

Winkler (51) classifies fractures about the ankle joint as fractures with dislocation or without dislocation. He states it is always wise to test the ankle for tear of capsule or ligaments at the site of the fracture by grasping the foot as a whole and attempting to push it toward the fracture zone. He states no twisting should be done or the test is of no value, and he feels that if the ligament or capsule on the side opposite the fracture has been torn the patient immediately winces or feels pain in the fracture, and that such a positive response to the test should result in immobilization of the ankle in plaster longer than if the test is negative. He feels that cases with proven ligamentous tears should be immobilized at least six weeks.

Kaye (52) presents a concise carefully written review of fractures about the ankle joint in children and in adults with excellent discussion of anatomy and physiology primarily favoring closed reduction. However, he feels that open reduction should be done within 48 hours after injury

if manipulation can not reduce or maintain the reduction.

Callahan (53) describes fractures of the internal malleolus as simple or complex, the latter term recently popularized by Conwell as designating simple fractures complicated by blebs or lacerations of the skin. His article concerns only fractures in which reduction is unsuccessful and those in which conservative treatment is necessarily prolonged because of skin complications. He feels that fibers of the transverse ligament frequently complicate the problem by preventing complete manual reduction by stretching between the fragments or tendons and that this ligament can be removed only by surgery. He emphasizes the danger of accepting as good enough reduction one which is neither adequate nor anatomic, and feels that accurate reduction is important because failure promotes painful ankles and feet, altered weight bearing and arthritic changes. He warns against procrastination in surgical treatment of fresh fractures in which initial attempt at reduction is unsuccessful. He feels that the longer surgery is postponed, the more difficult it is to perform and the more uncertain the end result.

Fractures of the Foot: - Otten and Mumford (54) report novocaine injection treatment of metatarsal fractures used in 62 cases. In their hands the disability was an average of 11.6 days in 35 cases injected with novocaine, 47.3 days in 14 cases immobilized in plaster of paris, 32 days in 5 cases injected and immobilized in plaster of paris, and 22.6 days in 3 cases injected and strapped. They infiltrate the fracture line with 10 cc. of 2% novocaine and make an attempt to gain normal anatomical reposition of fragments. They feel that it is essential that any plantar angle be corrected, but lateral displacement is not objectionable. The patient is advised to use crutches but to have weight bearing to some extent to the point of pain. The authors use no immobilization or splinting either with adhesive or plaster of paris, and the patient returns to work when pain upon full weight bearing is such that work can be tolerated.

Palmer (55) describes fractures of the calcaneus as a linear fracture of one of three types, avulsion, compression or shearing, and describes in detail with excellent drawings the anatomy underlying the types. He feels that the shearing type of fracture is intra-articular and comprises the largest group, at least 50% of all fractures of the calcaneus, and he found that most patients who sustained this type fracture had a permanent disability of 25 to 33-1/3%. In performing arthrodesis of the sub-talar joint for this condition, the author found that a ledge was created in the joint which sometimes reached the height of 10 mm. and feels that this ledge is due to compression of the substance of the calcaneus itself. He presents the treatment divided into three steps: (1) reduction of the entire lateral block of the shearing fracture, (2) reduction of the secondary compression fracture involving the articular surface and (3) filling the bony defects which result from elevation of the articular fragment from the normal position. The author puts a graft from the crest of the ilium into the defect left by the compression after reduction. He uses a short leg cast post-operatively, allows the patient to walk 2-4 days after the operation with crutches, and after 12 weeks replaces the plaster by a zinc-paste stocking and strong shoe with longitudinal arch support. He

reports 23 cases with all patients back at previous work from 4-8 months after the operation, with painless pronation and supination in the subtalar joint of 15-30 degrees.

Fracture of the Os Calcis: - Miller (56) presents an overall review of the modern treatment of fractures of the os calcis not including the methods presented by Ivar Palmer, and calls attention to the fact that most patients with fractures of the os calcis have swelling of the foot after the fracture has united. This is worse in older patients or where there has been gross injury. He treats this by contrast bathing, by regulated exercises, and by a detachable pressure bandage. He feels that some permanent broadening of the heel may remain due to soft tissue fibrosis and feels that stiffness is usually due to post-traumatic adhesions in the tarsus and resultant lack of mobility in the foot. He recommends mild manipulation followed by active and energetic exercise.

Medullary Nailing: - Wiggins and Lewis (57) of the United States Navy report their experiences in 6 cases of fracture of the femur in which intramedullary nails were used to supply the internal fixation. The intramedullary nail utilized in the cases reported were 18-8 SMO stainless steel, 15" in length, 5/16" or 3/8" outside diameter, and .35" in thickness. The nails were flattened in order to accommodate the handling of the guide. The open type of operation was employed in introduction of the nails in each case. In the first two cases of the series no external immobilization was employed during the post-operative period, with deferment of weight bearing until clinical and roentgenologic union had occurred. The complication of bending of the nail in the third case led the authors to the use of post-operative skeletal traction immobilization in the remainder of the series. The cases are described in detail. The authors offer the following comments and conclusions: The intramedullary nail may be substituted for other methods of fixation when open reduction is necessary; intramedullary fixation is not indicated except in femoral fractures, and only in those in which closed reduction has failed or which for other reasons must be openly reduced. The two serious complications which occurred in this series were re-fractures and bending of the nail. No post-operative infections occurred. The authors are of the opinion that the American manufactured rolled sheet stainless steel available to them is not strong enough to provide satisfactory fixation in all individuals.

Westerborn (58) reported on his experiences in 100 cases of marrow-nailing of recent fractures, pseudarthrosis and bone plastics. The author employs either the closed or open method after reposition, as the situation demands. The nails used in his cases were manufactured by Ericsson's Instrument Company in Gothenburg, Sweden. The nails were of rustless steel. The first nails were not sufficiently strong and were bent at the time of insertion or later through the strain of the fracture. The author points out that the hardness of the steel must be just right because if they are manufactured of too hard steel they are not flexible enough to conform to the shape of the medullary cavity when being introduced. The author believes that absolutely firm fixation is necessary for the proper healing of the fracture. For this, he points out, one must choose a nail which fits well

into the marrow cavity and ascertain that the latter is a fairly even width. This is the case in the cavity of the femur and to a certain degree in the radius and ulna, but not in the tibia and humerus. Thus, the best results are obtained in the nailing of femoral fractures. The nail must be wide enough so that it establishes firm contact with the wall of the marrow cavity, mainly in order to prevent rotation between the fragments. The size of the nail can be chosen by estimating the size of the marrow cavity in the roentgenogram. He states that, according to Fischer, with a focal distance of 75 cm. the marrow cavity is really 1 mm. smaller than it appears to be on the roentgenogram. The conditions are not so favorable in the tibia as they are in the femur, for here the cavity is narrowest in the middle. Consequently, it is easy to obtain firm fixation of the fracture situated in or about the middle of the tibia, but not of one situated more distally or proximally. The advantages of medullary nailing are great in these cases because the patients can be allowed up early and can soon begin to bear weight on their legs, avoiding stiffness in the joints and muscle atrophy. Another great advantage is that the patients are immediately rid of pain. It is also maintained by Kuntscher and others that the nailing accelerates the formation of callus, thus considerably reducing the time before the patient is able to resume his normal occupation. The author makes the point that when the nail can only be inserted 3 or 4 cm. in the distal fragment it is necessary to apply a plaster encasement for some weeks, and early weight bearing is out of the question. He also emphasizes that no definite agreement has been reached about the indication for medullary nailing, pointing out that while some surgeons have narrow indications, others have fairly wide ones. In considering the risks involved in this type of operation, the author is of the opinion that marrow destruction, fat embolism, and osteomyelitis are to be feared most. He says that experience has already shown that the damage which the nail causes to the bone marrow is of little practical significance. He recommends, however, that the nail be removed when full consolidation is established. As regards fat embolism, the author cites two deaths reported by Kuntscher and Habler, but since detailed information is lacking, it is not known whether the fat embolism occurred as a result of the fracture or of the nailing. According to reports in open fractures extensive osteomyelitis generally does not develop, but only restricted osteitis with local sequestration, mainly due to the fact that pus in the marrow cavity is led off along the nail. Thus, according to Kuntscher, Böhler, and others, there is never any enclosure of pus in the cavity with rising pressure which is generally thought to be the cause of extending osteomyelitis. The author is also fond of medullary nailing in the cases of pseudarthrosis, having nailed 24 cases of pseudarthrosis up to the time of the writing of the paper. In a follow-up of these cases bone healing was satisfactory in all but three cases where inflammation recurred after operation. The author goes on to advise that in order to hasten bone healing the marrow nailing may be combined with other operations such as bone transplantation, either in the form of chips or with a larger piece of bone. The method is also useful in cases requiring bone lengthening or bone shortening to cover a deficiency of bone. The author includes 15 case histories to illustrate the points cited in the review.

Hedri (59) reports on 82 cases of intramedullary nailing of fractures of the femur, discussing the pathology, complications, indications and technique. The author states that, judging from cases on record, no sequestration and no fistulae develop if there is no infection. Undisturbed and smooth development of callus has been proved by animal experiments, and by surgical results in 82 cases. X-ray control films demonstrate that ossification of the ends of the fragments is perfect. In his opinion the fracture itself, by its violence, causes worse medullary destruction than does this method of nailing. None of the 82 cases in the author's practice died of fat embolism. The effect of the operation on the marrow as a blood generating organ was found to be as follows: red blood cells increased to between 10% and 30% with a corresponding rise in hemoglobin; in many cases the thrombocytes and reticulocytes increased by 50%; there were no noticeable changes in the leukocyte counts; the qualitative blood count showed juvenile forms, with a lively increase in eosinophiles, in some cases as much as 8% to 10%. He concludes that medullary nailing is apt to stimulate the blood generating activity of the marrow. The most serious complication was infection. Suppuration occurred in 4 cases (6%). All these cases with suppuration were old compound fractures with osteomyelitis and mal-union, or cases healed with a false joint. None of the infected cases had the advantage of penicillin. In discussing the indications for intramedullary nailing the author includes: (1) badly consolidated fractures of the femur; (2) those healed with a false joint; (3) such new fractures of the femur which cannot be dealt with by conservative means; and (4) where open reduction with internal fixation is indicated. Regarding the question of "open nailing" versus "closed nailing", the author has adopted the open method because old fractures such as badly consolidated fractures and non-union have to be laid open anyway. The open method is also applied to fresh cases because the nailing is much less difficult than by the closed technique.

Fraenkel (60) records his observations in intramedullary nailing of fractures. The following details were extracted from a careful analysis of 155 cases operated on at Kiel from January 1, 1944 to May 1, 1946. Femur: - subtrochanteric fractures are very satisfactorily controlled with a short special nail. In the shaft a guide pin is usually employed and it or the nail is of help in manipulating the upper fragment. In supracondylar fractures the nail is of great value in obviating angulation, but additional immobilization is required because of the width of the marrow cavity. Of 35 simple fractures, 27 were stable. The others required additional immobilization, but angulation was absolutely prevented. In the stable cases, the patients started walking in 7-42 days. No nails were removed before 4 months. Of 7 compound fractures, 3 were stable without additional immobilization. All united and only 1 case, with gross loss of soft tissue, had loss of function. Four pathological fractures were nailed and irradiated and 2 osteotomies were nailed with excellent union. Tibia: - Owing to the hourglass shape of the marrow cavity, a special double nail is inserted from the region of the tuberosity or of the medial malleolus. The first nail carries a wedge which forces away from it the following second nail, thus securing the lower end firmly. Of 46 simple fractures all those put up with the double nail were stable; but 10 nailed with a single nail because of multiple fractures which the double nail could not pass, or for other reasons, required additional plaster. Even in these cases the position

was far better than could have been otherwise achieved. No nails were removed before 3 months, and there was difficulty in extraction in 2 cases. Of 15 compound fractures, 14 were stable. Humerus:- This can be nailed with ease from below or above. The early and full function of the arm and hand is remarkable. Ten closed fractures were all stable and received good union with good function. Nailing of 2 pseudarthroses with freshening led to good union. Radius and Ulna:- The radius is nailed from the lower end and the ulna from the upper end. The stability of this method of fixation offers great advantages here but reduction may be difficult. In 16 fractures open reduction had to be used in 6 cases. All united well except one worker who started heavy work 4 weeks after injury without medical consent. The nail was broken and a pseudarthrosis developed in the ulna. This united after extraction of the nail, freshening and renailing. Nails were left in at least 3 months. The author's impression is that the advantages derived from early and anatomical union, and from the full joint and muscle function, preserved throughout, outweigh the disadvantages which are mainly the necessity for a moderate amount of apparatus and for screening. The dangers of sepsis and fat embolism appear to be largely theoretical and there is ample evidence that the nails have no adverse effects on the bone marrow.

Devices for External Fixation:- Spriggs (61) discusses the employment of the Haynes splint treatment in fractures of the long bones. In his opinion the advantage of this type of splint is that it makes possible the achievement of anatomical reduction of fractures combining the principles of internal and external fixation without the necessity of open operation. A detailed description of the appliance is given. The author concludes that the advantages of this type of treatment are: (1) motion of joints proximal or distal to the fracture, (2) better attention to the skin in simple fractures, (3) fixation of compound fractures while the wound is being cared for and (4) early and easier mobility of patients with resulting reduction in nursing care. Complications:- There was non-union in 2 cases, and in three cases an infection developed severe enough to require removal of the splint. In general, there appeared to be some delay in union of fractures treated by this method as compared with the expected healing time of fractures treated by the usual conservative method.

Waugh (62) discusses external skeletal fixation used with ordinary extension splints in the treatment of fractures of both bones of the leg. The author feels that even though some writers criticize the use of external skeletal fixation there is a definite place where this method can be used; for example, badly comminuted, compound, or oblique fractures of both bones of the leg are fractures which can be treated most satisfactorily by pin fixation. This is particularly true when the surgeon understands the basic principles of fracture treatment as well as those pertaining to the application of pin fixation. In 1926 the author described a simplified method of skeletal traction and counter-traction using a special pin holding clamp combined with ordinary extension splints. After further experience the author states that he is more enthusiastic than he was at that time in endorsing this simplified method of external skeletal fixation. He described this technique and equipment in detail including a discourse on equipment, application of the transfixion pin, technique of reduction and skeletal fixation in plaster.

Key (63) discusses the complications of treatment of fractures by external skeletal fixation, and points out that the ingenious fracture reduction machines and external skeletal fixation splints require considerable skill for the successful use on patients. Their use is not without danger and the following complications have been noted: (1) Infection around the pins which may involve the bone and even become extensive or generalized, (2) non-union which is believed to occur more frequently in fractures treated by this method than in those treated by more conservative methods or even open operation and internal fixation, (3) failure of satisfactory reduction with resultant deformity, (4) damage to important anatomic structures by the pin, (5) injury to joints and (6) Sudeck's post-traumatic atrophy.

Devices for Internal Fixation:

Harmon, Baker and Reno (64) report the results of experiments on the holding power of various types of metallic internal fixation for transcervical fractures of the femur. The data summarized in this report were secured in experimentally produced fractures across the femoral neck of 242 selected specimens. The estimations were of two types: the holding power against a distracting force directed coaxially with the neck and a determination of the resistance of the specimen to a superior, inferior crushing force. The experimental method used and the materials employed are described in detail in the article. Results of the tests are described in a well arranged table. Twelve types of internal fixation materials that are commonly used in the treatment of transcervical fractures of the femur in man were employed in the tests. Included in the devices are multi-bladed nails, steel flanges, Steinmann pins, special slender pins and screws and various types of lag screws. Conclusion: Fractures immobilized by the hexagon headed, slender, stainless steel screws yielded the highest value on resistance to both distraction and crushing; the holding power of these screws against a distracting force was increased 45-75% by reinforcing the trochanteric and upper lateral femoral cortex with stainless steel washers and plastic plates; These values even exceeded the force required to pull the femoral head from an unfractured specimen. All the devices tested showed up well on crushing; especially high values were observed in the test for the Smith-Petersen tri-bladed nail, several Steinmann pins, the various lag screws, and multiple long hexagon headed screws. The results are given in 53 cases of transcervical fracture in man treated by early reduction in which the long hexagon headed screws were used for fixation. Direct union without other procedures was observed in 84.9%. Trochanteric osteotomy within 6 months after fracture was performed in 6 cases. The two instances of non-union were observed to follow reduction failure in one instance and to fracture of the screws in an unreasonable and hyperactive patient in the other. There were no instances of necrosis of the femoral head. The minimum follow-up period was one year and several patients were followed for six years. The long, slender, hexagon-headed screws serve as their own guide or pilot pin. They are introduced atraumatically with a drill and can be withdrawn and re-inserted easily and without damage to the bone. The depth of insertion can also be adjusted after control roentgenogram.

Lee (65) reports 42 cases of fracture of long bones treated by open reduction and screw fixation. Mentioning the disadvantages of traction methods he includes the requirement of constant supervision in order to

insure the maintenance of the fragments in the correct position, the necessity for prolonged hospitalization, the danger of distraction of the fractured surfaces, and the likelihood of angulation of the fragments. In outlining the advantages of screw fixation he includes the following: only a minimal period of hospitalization is required, the elimination of the danger of distraction, the possibility of early weight bearing, and the general improvement in the patient's morale when early weight bearing is possible. In his opinion indications for internal screw fixation are: those cases in which one of the fractured ends do not permit locking of the fragments or in which strong muscle forces tend to maintain the fragments in displacement; when manipulative or traction methods have been tried and have failed; in the compound fracture in which a debridement leaves the fracture area widely exposed; in special cases such as in fractures of the shaft of the humerus when complicated or retentive dressings or apparatus must be worn causing discomfort for an obese patient; and in patients who prefer operative treatment in order to shorten the period of hospitalization. The author outlines the operative procedure in detail and includes a careful analysis of the 42 cases reported upon.

Adams and Coonse (66) discuss their experimental work in connection with the development of a method to obtain complete rigid fixation in fractures of the long bones by double plating. With the help of mechanical engineers a guide bar was developed for placement outside the wound with a tunnel guide running to the bone. The guide bar was gauged to the holes in the plate. Two yokes were then developed which were fastened to the bone itself and a reduction bar connecting them. The perfected machine attained the desired result in that the authors were able to place two plates on the bone over the fracture line and have the holes directly opposite each other. Stainless steel 18-8 was used throughout. The method was used on eight cases and all but two showed very definite aseptic necrosis the cause of which was found to be tortional strain plus lateral compression. The authors came to the conclusion that the mechanical results of double plating definitely produced rigid fixation, but that Wolff's law functions today as it has done in the past, and feel that this method should be thrown into the discard.

(Ed. note (OSR): I agree that the procedure outlined by the authors should be discarded, but do not concur in the idea of abandoning the principle of double plating of fractures of the shafts of long bones. I have had the privilege of performing over 20 open reductions on the femur, in each instance using two stainless steel slotted plates for internal fixation. The plates were placed at right angles to each other, one on the anterior surface of the femur, the other on the lateral surface. The plates were centered over the fracture site, but were offset from each other just enough to allow placement of the screws. Aseptic necrosis did not occur in any case. In the fresh cases, the patients were ambulatory in two weeks without any additional support.)

Follis (67) discusses and illustrates the types of fixation he considers indicated in open reduction of fractures. Three procedures are outlined and illustrated with suitable cases along with their x-rays. First, two cases demonstrate the application of the wood screw principle

to oblique and spiral fractures. Second, cases are shown to illustrate the use of bone plates in transverse fractures, and third, two cases are cited in which transverse fractures of the femur were treated with bone plates and no cast applied. The author believes that frequently when firm fixation is secured the cast can be eliminated especially in limbs that are not heavy.

(Ed. note: Angulation of the fracture is liable to occur when only screws are used for fixation unless the cases are very carefully selected and unless the post-operative splints are very carefully applied and maintained until the fracture heals.)

Blade Plate Internal Fixation:- Umansky (68) reports a case of fracture of the distal end of the femur in which he employed a blade plate for internal fixation of the fracture. There was an oblique fracture through the lower one-third of the shaft of the femur with marked lateral displacement of the distal fragment and about 2" of overriding. Accordingly, skeletal traction with a Böhler-Braun splint was applied. Five weeks later there was an absence of callus and a continuous separation of fragments and great discomfort experienced by the patient. The fracture was then openly reduced and held in position with 3 screws. Ten days later a roentgenogram showed that separation of the fragments had taken place and also that one of the screws had caused further fragmentation. It was then decided to apply a blade plate for internal fixation of the fracture. At operation the previously inserted screws were removed as well as three rather large bony fragments. The angle of the blade was increased and the plate gently curved outward at the angle to conform to the lower lateral end of the femur. A blade $3/4$ " shorter than the x-ray image of the proposed course was selected. The point of the blade was inserted about 1" proximal to the lateral condyle in order to avoid the knee joint and stripping of the suprapatellar pouch. With a small osteotome a cut was made in the femur at the site and the blade was driven in for $2/3$ rds of its length securely anchoring the distal fragment. This was levered into the correct position by elevation of the plate parallel to the horizontal table top. The proximal fragment was then approximated to the distal fragment, and the blade driven home. Two Lowman bone clamps were used to hold the plate to the shaft of the femur while screws of appropriate length were inserted into the bone ends.

Fractures of the Spine and Pelvis

Crutchfield and Schultz (69) discuss the mechanism of the common spinal fractures. Regardless of mechanism of injury the resulting deformities of the vertebral canal are constant. The vertebral canal is narrowed in its AP diameter by dislocation. Crushing injuries with wedging and posterior displacement of the fragments into the canal are commonly seen in the thoracic region. Complete obliteration of the canal is seen in some of the more serious cases. The clinical picture of complete and incomplete transverse cord lesions is described. The treatment of these injuries is outlined in detail. Most impressive is the statement that no indication for cervical laminectomy has been found. The general care of the paraplegic is described in detail.

Holdsworth (70) presents a series of fifty cases of disruption of the pelvic ring either by sacroiliac dislocation or fractures of the ilium or sacrum close to this joint. The former is twice as common as the latter. These cases were treated with pelvic slings after reduction. Complications were unusual - only two with extraperitoneal rupture of the bladder, both of whom died; two with rupture of the urethra survived. Eight developed retroperitoneal hemorrhage probably due to laceration of the iliolumbar artery - four of them died. The prognosis in fracture - dislocation is good. Nearly all patients returned to heavy work. However, with sacroiliac disarticulation, the prognosis is not so good - only half returned to heavy work and there was often persistent sacroiliac pain. Arthrodesis of the sacroiliac joint was advised in these cases.

Gallagher (71) presents four cases of fracture of the anterior iliac spine and indicates that the condition should be suspected when sudden severe pain develops in the inguinal region following either strenuous exercise or twisting of the hip in poorly conditioned adolescents. The pain is excruciating and there may be difficulty in walking and vomiting. Inability to raise the extended leg is constant. X-ray will prove the diagnosis. Treatment consists of bed rest for 2-3 weeks with knees and hips flexed and then gradual activity.

Davis (72) presents a series of 150 consecutive compound fractures treated by primary suture. One hundred and thirty-one, or 87% of the wounds healed by first intention. The author bases his excellent results on compression dressings, immediate coverage of the skin defect with skin or a split skin graft and thirdly to immediate or delayed internal reduction with metallic fixation when indicated. The use of penicillin, transfusions of whole blood and high protein diets also played an important role in the healing. Healing by first intention was found to be more frequent when radical excision of devitalized skin flaps was carried out. Relaxing skin incisions was the preferred method of skin closure with the resulting donor defects closed by split skin grafts.

Special Fractures

Astley and Shaw (73) present a case of fracture of the first rib bilaterally through the scalene tubercle due to the pull of the scalene muscles in a poorly trained individual under the sudden strain of strenuous physical training.

Burman and Sinberg (74) describe fracture dislocation of the xiphoid. The xiphoid is seldom injured. The force injuring the xiphoid can be applied in only one way, from anterior to posterior. Four forms of injury are possible: (a) contusion or xiphoidalgia, (b) fracture at its junction with the sternum with stripping of sternal periosteum, (c) fracture at its junction with the sternum with posterior dislocation and (d) fracture with displacement into the mediastinum. Treatment of the minor injuries consists of heat, massage, procaine injection and elastic strapping. Treatment of the more severe injuries not relieved by the above is by surgical excision.

Foster and Wells (78) present 13 of 14 cases among high school athletes demonstrating fractures which were not recognized although the athlete continued through the season without diagnosis or treatment. The authors have proven that this is not an uncommon occurrence and demonstrate the need for medical surveillance of high school athletics. Some form of health insurance protection for these boys is desirable. These injuries most commonly involve the hands, feet, wrists, forearms, ankles and lower legs. Football is the outstanding producer of such injuries.

Clough (79) describes various stumbling blocks in the treatment of fractures. Specific fractures are considered. Fractures of the navicular prove difficult often not only in diagnosis but in obtaining union. The bipartite scaphoid will occasionally make diagnosis more difficult. The importance of accurate anatomical reduction of the radial fragment in a Colles' fracture is discussed. The treatment of supracondylar and surgical neck fractures of the humerus are described. The author advocates internal fixation of all fractures of the femoral neck. He advises against promising too good a result in such cases because he thinks 70% good results ~~as~~ as can be expected.

/are as good

Ciccone and Richman (80) discuss a series of 2,709 fractures resulting from parachute jumping in regard to mechanical etiology. Four recurrent traumatic mechanisms became evident. The most common mechanism was torsion plus "landing thrust". Backward landing caused by oscillation of the parachutist was a common cause of vertebral fractures and craniocerebral injuries. Another mechanism of injury discussed was that due to opening shock of the parachute resulting in an arm or leg becoming entangled in the shrouds. The least common of mechanisms of injury was the violent vertical fall usually resulting in multiple injuries involving the major weight bearing structures.

Ainsworth and Wright (81) report their experimental studies of fracture sites. Simple, compound and traumatized compound fractures were produced experimentally in dogs. The dogs were sacrificed in the 2nd, 5th, 7th, 15th and 21st days and serial sections through the fragment ends made. The cortical portion in the area adjacent to the fracture showed the lacunae to be entirely devoid of cellular content and the Haversian canals had undergone marked destruction. The most widespread devitalization was near the periphery of the cortex and the least in the marrow cavity. The least amount of devitalization was seen in the simple fractures and the most in the traumatized and compound group of fractures. The authors conclude that in the reduction of a fracture, devitalized tissue is approximated with devitalized tissue and the removal of this must be accomplished in the physiology of healing before solid bony union occurs. This tissue appears to have a local effect on the chemical composition and reaction of the hematoma and granulation tissue.

Healing of Fractures

Bick (82) discusses the structural patterns of callus in fractures of the long bones with reference to healing after internal fixation.

Scuderi (75) discusses the more common sprains and minor fractures as to etiology, pathology, symptoms and signs, diagnosis, and treatment. The importance of x-rays to rule out associated fracture is stressed. The two classical forms of treatment - immobilization versus local injection plus the use of the sprained joint, are discussed. Certain common minor fractures, particularly those of the phalanges, are discussed. He stresses the treatment of the fracture-sprains of the ankles and wrist by immobilization in the over-corrected position. The importance of early diagnosis of subperiosteal fractures as well as their common sites is stressed.

Cleveland (76) compares the total casualty rates during the recent war and those arising due to accidents in civilian life during the same time. Soldiers and sailors in combat and in training were exposed to hazards only ten times as frequently as civilians. Various emergency treatments were discussed. The emergency splinting of the lower extremity involves the use of the Thomas ring splint. For fractures of the foot and ankle wire ladder splints should be used. For fractures of the humerus a sling and swath should be used. For fractures of the forearm, wrist and hand, a well padded wire ladder or basswood splint should be used. Resuscitation from shock involves the use of whole blood, not saline and plasma. The author discusses debridement and the importance of conserving all viable tissue. Similarly the secondary closure of compound fractures is emphasized. All bone fragments should be preserved if possible. Amputations should be low as possible and circular in type.

Gurd (77) has presented 25 pitfalls into which the unwary often fall in the treatment of fractures. These errors are divided into three classes depending on when they occur - before, during actual treatment, or during the healing period. The first and most serious error is the failure to assess the severity of associated traumatic shock. The failure to diagnose concealed non-bony injuries and all concomitant fractures is stressed. Failure to obtain adequate pre-operative x-rays and failure to interpret x-rays properly are pointed out as pre-treatment errors and in addition, failure to identify films is stressed as a not uncommon example of the wrong patient being treated. Proper recognition of the mechanism of production of the injury is recognized as of extreme importance for future treatment. Adequate medical records and the importance of notifying all concerned of the prognosis, are stressed. Among the serious errors resulting during treatment of fractures are delay in fixation, delay in reduction and inadequate reduction. Repeated attempts at reduction and the use of excessive padding under plaster lead to unfavorable consequences. He lists a broad group of technical errors during open operations and in treatment of compound fractures, particularly primary suture. The remaining errors occur during the healing period of the fracture. The failure to maintain close observation, failure to check maintenance of reduction, maintenance of an extremity in a non-physiologic position, the application of unpadded plaster in the presence of edema, the failure to instruct the patient in the use of prescribed appliances, too early mobilization, delay in rehabilitation, and lastly too early and ill-conceived physiotherapy are all mentioned as too frequent errors.

After a series of tracings were made from unselected cases of fractures of the shafts of the long bones treated by standard nonoperative methods, Bick found regularly repeated patterns of the ossific mass about the fracture site. Only the structural outlines of the ossific mass was considered. The patterns appear to follow certain rules. These patterns of ossific mass about a fracture formed an external strut or brace temporarily holding two or more fragments in position and transmitting stresses outside the direct line of the axis of the shaft. While being held up by these ossific struts, physiological resorption and replacement of the bone ends of the fragments can proceed as part of the process of reparative osteogenesis without collapse of the fracture space. The "volume of the external ossific mass appears to be in direct proportion to the degree of displacement". The hematoma appears to have no influence on the development of the ossific mass. Where a plain undisplaced fracture exists the ossific mass formed is minimal while with total displacement it is greatest. The author stresses that the smaller amount of callus (ossific mass) seen with accurate open reduction and accurate fixation with plates or screws, etc., is dependent on the lesser displacement and should not be regarded as an indication of lesser callus because of plating or other metal fixation. He also points out that x-rays may be misleading in deciding the degree of healing. In his opinion clinical judgment of healing is more significant than x-rays in cases where internal fixation is efficient.

The author outlines his opinions on the criteria of healing in fractures following internal fixation. He points out the lack of any actual criteria of healing or even definitions of healing. He defines two pertinent phases in the tissue reaction of reparative osteogenesis; one of which he calls the phase of "effective healing" and the other the "phase of replacement". The phase of "effective healing" is defined as that phase of reparative osteogenesis in which the resistance of healing bones to stress and strain is sufficient to permit renewal of its normal functions within reasonable limits. In fractures of the long bones of the upper extremity this means manual work short of severe pressure or torsion; in the lower extremity it means ordinary unassisted weight bearing. The phase of "replacement" is defined as the phase of reparative osteogenesis during which the dense, fibrous fibrocartilaginous tissue of the internal callus is replaced by normally constructed bone trabeculae. This is said to occur concurrently with, but much slower than, the development of the uniting external callus which is the chief factor in the previously defined phase. Bick also is of the opinion that effective bone healing occurs in many cases long before x-ray films show completion of replacement by definitive callus. He found that in uncomplicated cases of rigid internal fixation, at least limited function could be resumed long before x-rays showed any of the accepted criteria of bone healing. He notes that James Paget and Dupuytren recognized the different functions of the "external or supportive callus" and the "internal or definitive callus" over a hundred years ago. In continuing the discussion the author states that in efficiently plated fractures the bone plate takes over the function of the external callus and permits resumption of the function of the bone as soon as its strength, plus that of the consolidated fibrocartilaginous material of the internal callus established effective healing. Before the "replacement phase" is completed the internal callus is radio-lucent thus leading to misinterpretation of degree of healing on x-ray

films. This "intersurface area" does not collapse during bone union and is filled with firm components of the so-called soft callus and is ossified eventually by replacement with bone cells and trabeculae. The appearance of considerable "external callus" in cases of internal fixation is indicative of either inadequate fixation or poor alignment. He found that in cases of efficiently plated fractures of the tibia and fibula guarded weight bearing could be started in six weeks. Uncomplicated plated fractures of the humerus required no plaster immobilization and guarded motion could be tested between the fifth and sixth weeks. Forearm fractures with either or both the radius and ulna plated required six weeks for safety. No time period for weight bearing on plated fractures of the femur was offered.

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SECTION 9

FRACTURE DEFORMITIES

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Ayyar (1) reviewed the deformities arising following trauma in a general manner. In a discussion of the etiology and prevention of deformities that arise from ununited fractures, malunited fractures, epiphyseal injuries, and unreduced dislocations, he lists stiffened joints, excessive shortening and malunion as causes of crippling. Lack of efficient after-care and of continuity of treatment is one of the causative factors. He states that,

"Every fracture should be looked upon as a potential deformity which may be traced to omissions and commissions or both; these may arise during treatment or after treatment."

He lists expert supervision, simplicity of apparatus, teamwork, segregation of fractures, and continued after-care as necessary to prevent deformities following trauma.

A malunited fracture cannot be cured by operation alone. The operation can only reconstruct the fracture. A satisfactory result can only occur by the maintenance of alignment until consolidation is complete. This period required for consolidation differs with each fracture. During the period of maintenance of alignment, the muscles and other tissues should be exercised and kept efficient to prevent soft tissue deformity.

The author reports that Volkmann's ischemic contracture is commoner in India than any other part of the world. Besides proper prophylactic measures to prevent the occurrence of ischemic paralysis, he also recommends early surgery. In the care of injuries of the elbow, such as supracondylar fractures, if the edema is not subsiding or if there is severe pain, he reduces the flexion angle of the elbow, elevates the extremity, and loosens all bandages. If these measures do not improve the condition he employs surgery. An incision three inches in length is made on the antero-ulnar border of the forearm, dividing the deep fascia and decompressing the forearm structures. He recommends exposure of the brachial artery at the bend of the elbow and above with resection of the artery if spasm is present. This must be done in six hours time. In the presence of the deformity he recommends early adequate splinting and encouragement of active movement.

In discussing traumatic myositis ossificans as a complication appearing commonly after injuries in the region of the elbow joint, the author advocates the prophylaxis as follows: reduce the dislocation promptly with minimum force; treat supracondylar fractures as an emergency and reduce them correctly; immobilize the elbow after reduction of elbow dislocations for at least three weeks, and restore movements of the elbow joint slowly in a case of supracondylar fractures. In restoring motion he gradually lowers the

elbow angle one-half to one inch every day. He watches for spasm of the biceps muscle. When this, or the traumatic ossification is noted, the elbow is rested, allowing active movements only. The new bone formation may shrink and the condition may gradually improve. He does not recommend operative removal of the bony masses and bridges before six months.

Phemister (2) discusses the causes of nonunion in fractures. These are local, and he lists the most important as: (1) inadequate fixation which permits of continuous trauma to the callus, (2) displacement of fragments which interfere with the establishment of a fibrous bridge and the impaction of coapted fragment ends by muscle pull, (3) infection of the fracture site, and (4) necrosis of the joint fragment in case of fractures bordering extensively on certain joints, such as the hip. If one or a combination of these factors remains sufficiently active beyond the normal healing time, the callus fails to ossify or even to fill out the space between the fragment ends, and non-union is established.

The author does not believe, as many do, that these fractures must be broken down, the intermediary and intramedullary callus removed, and a bone graft applied with metal screw fixation. He advocates a more simple and efficient operative treatment. This consists of the simple application of a strong bone graft to the leveled side of the fragments, suture of the overlying soft parts, and plaster immobilization for two to three months. Callus is thrown out from both the graft and the freshened surface of the shaft, and bony union is rapidly established between the two. The remaining old callus holds the fragments together and as motion is eliminated the intermediary callus, being less and less traumatized, becomes healthy and ossifies. He reports union of the fracture is usually present by the time the cast is removed. He recommends this treatment in case of fractures where the fragments are in good position.

He reports more than one-hundred such fractures have been treated in this simple way with reduction at time of operation. Failure of union occurred in but four cases. He believes that only a relatively small number of ununited fractures of the shaft are so widely displaced that it is necessary to break down the fracture line, remove the intermediary callus, and align and rigidly fix the fragments to the bone graft with screws or wires. (Ed. note: Many cases of nonunion of fractures are seen in which this simple operative approach to the problem can be used. The prolonged immobilization this method necessitates with the tendency to ankylosis of joints must be considered. In contrast, rigid fixation of fragments allows earlier mobilization of joints which prevents ankylosis.)

Annersten (3) reports his observations of five cases of pseudarthrosis ensuing in fractures of the clavicle. He reviewed three hundred and fifty cases. Pseudarthrosis occurred in one and three-tenths per cent of these cases. In the same period of time the percentage of pseudarthrosis ensuing from a fracture of the forearm was between two and three per cent. He warns against being indifferent in the treatment of fractures of the clavicle since pseudarthrosis occurs more commonly than generally supposed. All of his cases clearly illustrate the characteristics of a fracture of the clavicle, i.e., dislocation of the lateral fragment caused by the weight of the arm. It is this dislocation which he believes plays the dominant role in producing the symptoms associated with pseudarthrosis. Only in one case did the patient

complain of pain at the site of fracture. The remaining patients all gave a history of pain radiating down the arm, often accompanied by weakness of the arm or the hand; one patient complained also of sensory loss over the fingers. These symptoms were less pronounced during the treatment when the arm was fixed because the lateral fragment was thereby kept in an elevated position. After immobilization was discontinued and the fracture failed to heal there was again depression of the lateral fragment and troublesome symptoms become manifest. These symptoms accompanying the nonunion are similar in type to those which are produced by compression of the brachial plexus and observed in the scalenus-anticus syndrome. The costoclavicular space is narrowest between the first thoracic rib and a point lateral to the middle-third of the clavicle. It is just this point which is most liable to injury and here the ulnar portion of the brachial plexus crosses above the first rib. The lateral fragment can readily squeeze the brachial plexus here, particularly if abundant callus is present which is often formed despite the fact that the fragments have not united. A clavicular fragment which is displaced downward, may also cause compression on the brachial plexus.

Satisfactory results were obtained in these cases after operative reduction with reposition and wiring with drilling of the bone. The best results were obtained by the insertion of bone chips between the fragments and immobilization by an aeroplane splint for four weeks. In one case the symptoms of which the patient complained were made worse when during operation the fragment was lowered further. Since the weight of the arm causes downward displacement easily in these fractures, and the symptoms produced by nonunion seemingly are dependent upon this depression of the lateral fragment, the author believes that in treatment of fractures of the clavicle it is important that the arm should be raised and adequately supported until healing is complete.

Wagner (4) presented a comprehensive paper on the treatment of metacarpal fractures, as well as the causes of malunion. He stresses the fact that the hand and fingers should not be overly immobilized. He also discussed the cause of disability brought about by immobilizing the fingers in extension. This produces capsular thickening and extension contracture of the metacarpophalangeal joints. The functional position of the fingers is stressed in treating metacarpal fractures.

In treating malunion of metacarpal fractures, an operative procedure as employed by Bunnell is presented. This has given full function in the author's hands.

Rizzo and Lehman (5) presented a procedure for treatment of large bone loss of the tibia without the use of metallic or other foreign substance to maintain the position of donor grafts. This procedure was used by the authors because they observed that foreign material introduced into a healed compound wound caused an increased incidence of flare up of infection. The procedure used was as follows:

A donor graft is removed from the longer of the tibial fragments, as long as possible. A second graft from the opposite leg measuring six to seven inches by five-eighths to three-quarters inch is inlaid in the site of removal of graft on the large fragment and inserted into the medullary canal of the shorter fragment. The other donor

graft is placed on a prepared area of the lateral or medial aspect of the tibia. Bone chips are placed in the space between the grafts. Plaster immobilization is used until healing is complete.

The author reports employing this technic in six cases with one hundred per cent success.

Scuderi (6) reported his successful experience in performing ninety-four massive bone grafts in treatment of long bone defects, with the loss of three grafts due to infection and a fourth one due to refracture, requiring a second graft. He concluded that, in treating this type of defect, no definitive bone work can be performed until all the bone and soft tissue infection has cleared up and has remained clean for a minimum of three to four months. To obtain this, it was necessary to carefully debride the wounds, remove all dead bone and foreign bodies. Most of these cases were successfully treated by the careful cleansing of the infected area, without sacrificing healthy bone or healthy soft tissue. Many of these cases so treated could be closed by interrupted black silk sutures, and then treated as a closed wound, instead of the old, well-known Orr treatment. The use of antibiotics permitted a great deal of surgery which formerly was impossible. Eighty-five per cent of chronic osteomyelitis cases in battle casualties so treated healed by primary intention. Fifteen per cent broke down and required further surgery. In some cases, in order to close the defect it was necessary, in deep, wide wounds, after a thorough cleansing of the area and packing for three to five days, to place a dermatome skin graft into the defect. In most of these cases primary healing of the skin graft was obtained. At a later date skin grafts of a full thickness type were used to fill the defect, either as a swinging graft or as a pedicle graft from the opposite leg. The author used three types of bone for restoring the bony contour in defects of bone. Cancellous bone from the wing of the ilium was excellent for filling in defects. When besides bridging of defect, mechanical stability was necessary, tibial bone grafts were most efficacious. Crest of the tibia was used when mechanical stability in addition to fresh bone was desired, as in the humerus and the femur. Tibial grafts from the central part of the tibia were used more commonly in the radius, ulna or fibula. Fibular grafts were found to be excellent where a large area had to be bridged such as a defect of five or six inches. The author's personal experience showed they served beautifully in the reconstruction of the radius and ulna or in the filling in of a large defect of the humerus or femur. Fibular grafts were used in conjunction with tibial grafts to fill in defects in the femur. Firm apposition against the host bone was obtained by preparing an accurately fitting bed to permit maximal bone contact. Stainless steel screws were far superior to any other form of internal fixation. These bone grafts required a long period of external protection. Plaster of Paris was found to be the best external support for a bone graft. Grafts of the femur required five to six months immobilization followed by three to six months thereafter in a walking caliper. Tibial and humeral fractures required three to four months immobilization and later support by various types of braces.

Farrow (7) records the experiences of bone grafting with autogenous bone in the treatment of 156 cases of fracture of the long bones with non-union or limited union, sustained as a result of war injuries. In 19 cases of limited union the bone was restored to approximately normal calibre. In 119 cases of non-union with known end results, successful union was secured in

104 (87.4%). Optimum time interval after drainage had ceased was discussed, quoting 72 cases with known time intervals. In fifteen patients operated upon after one to three month intervals, 40 per cent developed infection; in 39 patients operated upon after three to six months, infection developed in 20.5 per cent. No infection occurred in 18 patients operated upon after intervals of six to eight months. The author suggests it is unwise to substitute penicillin protection for an adequate waiting period.

Rankin (8) presented a resumé of his experience in performing one hundred consecutive bone graft operations in a naval hospital during World War II. These cases necessitated grafts for nonunion of fractures or those that presented defects to be bridged. The majority were performed in cases of war wounds that had previously had draining wounds. He concluded that the time element in the original treatment, the type of fracture, and the surgeon all contributed to the occurrence of nonunion in fractures. He applied grafts to the following bones: mandible 6, clavicle 4, humerus 7, radius 16, ulna 13, radius and ulna combined 9, scaphoid 10, thoracic cage defect 3, femur 10, tibia 18, internal malleolus 4. Four cases showed a small pocket of pus at the time of operation. The bone grafts were completed and the wounds were closed. Sulfadiazine was given as well as penicillin in these cases. One of the wounds healed per primum. Two wounds drained but eventually healed with preservation of the grafts and union of the fracture. In the fourth the operation failed.

Of ten ununited scaphoid fractures, six healed with bony union following grafting. Four returned to regular duty and two to limited duty because of some pain and about twenty five per cent limitation of motion. Four had no union but apparently enough fibrous union to return to limited status. The following fracture cases were sent to limited duty because of nerve injury: four radius, three radius and ulna, and two humerus. All the remainder returned to full duty. He concluded that of the patients treated by bone grafting for nonunion a high percentage should be able to return to normal activities.

In the humerus, femur, and tibia sliding inlay grafts were used principally. The recipient areas were prepared with osteoperiosteal flaps turned down over the graft when it was placed on the shaft. In bony defects dual grafts were used. Bone chips from the ilium were used in addition to bridge defects. Chip rib grafts were used for bone defects of the clavicle. Ribs and iliac grafts were both used in fractures of the mandible through external incisions. Often in these mandibular fractures preliminary intraoral operations were necessary to restore normal alignment because of shortening and deformity of the mandible. Stair-stepping the ends in some cases in humeri and forearm bones was used where it was not necessary to maintain normal length. This was of advantage where severed and retracted nerves were present. In the forearm this procedure or resection of the distal ulna, was used when it was impossible to maintain length of the radius. Thoracic cage defects were improved by transplanting ribs and good functioning and cosmetic results were obtained.

The author believes bone grafting is successful if certain rules are observed. Preoperatively the draining wounds connected with the fracture must be treated by the simplest procedure possible and extensive dissections and curettments are to be condemned. Proper skin coverage must be obtained

prior to any grafting procedure. A waiting period of approximately two months is recommended from the time drainage ceases until the bone grafting can safely be performed. This is due to the advent of the antibiotics. The waiting period can be utilized by physiotherapy to improve movement of joints and the circulation of the part. Penicillin is used pre- and post-operatively. At operation the author recommends the use of intravenous glucose and whole blood to compensate for loss of blood and body fluids. The draping should be done by the surgeon and not a third assistant; fine cotton should be used for ligation of vessels, avoiding mass ligation of tissue; and sponges are to be used once and discarded. The periosteum is disturbed as little as possible. All scar tissue is removed from the end of the bones and the medullary canal is opened widely with drill holes. Screws retaining the grafts are placed as far from the fracture site as possible and must traverse both cortices. Prior to closure a debridement of all devitalized tissue is performed, all dead space is eliminated, and the skin is closed with interrupted cotton sutures. (Ed. note: The opinion as to the optimum time interval between cessation of infection and surgery varies with the experience of different surgeons. Many advocate longer waiting periods than two months.)

Moore (9) discusses the statistics concerning fractures of the neck of the femur. One of the best statistical reviews is the report of the fracture committee of the American Academy of Orthopaedic Surgeons in 1941. Two hundred and forty one cases were reviewed. The Smith-Petersen nail was used in 144 cases, the percentage of union was 72.9; multiple pins were used in 83 cases, the percentage of union was 62.7; miscellaneous internal fixation methods were used in 44 cases, percentage of union was 85. Of the cases reduced successfully, approximately 24 per cent showed arthritic changes with pain, stiffness and disability in the two year follow-up. Faulty reduction possibly accounted for 75 per cent of the failures. Loss of blood supply to the head possibly accounted for 25 per cent. There appears to be a very definite group, approximately 15 to 20 per cent, which fail regardless of reduction and type of internal fixation. It is this hopeless group in which there is loss of blood supply to the head for which some type of reconstruction operation is essential.

Moore presented a reconstruction operation for nonunited fractures of the neck of the femur. This was based primarily on the utilization of the cartilage of the head of the femur at operation. He utilizes the dead head or the live head of the nonunion. He removes the bony contour of the head completely with the exception of the layer of bone attached to the cartilage. After a section of the trochanter is removed with the muscle attachments, he then carefully replaces the reamed-out cartilaginous cup of the proximal end of the femur. He reattaches the trochanter to the shaft of the femur with the aid of wire suture or vitallium screws. The method consists essentially of transplantation of hyaline cartilage. The author states the procedure is not successful unless the cartilaginous cup is accurately fitted to the neck and maintained in this relationship until it is united. The average time for union is between eight to twenty weeks and the patient is immobilized in a plaster of Paris hip spica. The author presents no statistical follow up on patients treated by this method.

Ivins and Ghormley (10) presented their evaluation of the Brackett operations performed from 1920 to 1945. Seventy one cases had this procedure,

with fifty per cent of these performed in the last three years. Thirty two per cent had undergone one or more operations elsewhere previously. Eight cases were discarded because follow up observations were not adequate, leaving sixty-three cases for analysis. The operative technic employed, especially in the later group of cases, was the Brackett operation as modified by Magnuson in 1932. Internal fixation of some sort was used in fifty five cases, or seventy seven and five-tenths per cent. Vitallium screws were used in forty-four cases and this was their internal fixation of choice.

The results showed one hospital death, or a mortality rate of one and six-tenths per cent. The results were: Good - 66.6 per cent; fair - 14.3 per cent; and poor - 17.5 per cent. (Favorable - 80.9 per cent). Of the eleven cases of failure, four had slipping of the head from the shaft, three cases showed typical aseptic necrosis, and in one nonunion developed with absorption of part of the head of the femur. One did not stop using crutches due to other causes occurring eighteen months after operation. One case of nonunion showed union between the head of the femur and the acetabulum at later operation and another was a failure because pain persisted after the operation. The authors recommend the procedure. They regard the proper selection of cases, careful operative work, valgus position of the femoral head on the remodeled shaft and adequate internal fixation as the factors which determine the success of this procedure.

Dickson (11) presented an excellent paper on the subject of treatment of ununited fractures of the neck of the femur. He confined his discussion to those cases in which it would seem possible and feasible to restore anatomic and physiologic function to the hip joint. He believes that when it is recognized that nonunion is developing the fact should be accepted immediately and an appropriate operation for correction carried out. When nonunion once starts it almost invariably goes from bad to worse, and delaying surgery allows atrophic changes to develop in the head of the femur. This makes the end results of secondary treatment more problematic. The earlier the operation is performed for nonunion the better the results that can be expected. The author discussed the advantages and shortcomings of various accepted methods of handling the problem of nonunion. An analysis of his results with varied procedures as well as a review of the literature showed that the proportion of failures, amounting to thirty-five to fifty per cent of all cases subjected to secondary procedures, was remarkably similar in all methods.

The author proposed a procedure to combine the advantages of the various procedures -- osteotomy, internal fixation, and bone graft. The aim is to correct the faulty mechanics by lowering the shearing angle to restore circulation and to stimulate formation of bone all in a single operation.

Technic: The trochanter is exposed through a lateral curved incision between the tensor fascia lata and the gluteus medius. The outer surface of the bone is prepared for a blade plate. The joint capsule is opened and a guide wire is placed from a point about one-half inch above the prominence of the greater trochanter into the center of the head. Then a blade plate is bent to form an angle with the shaft of sixty degrees when inserted parallel to the guide wire. The blade plate is then properly placed. The osteotomy site is determined by a proper size semi-hexagonal chisel. One side of

the chisel parallels the flare of the trochanter, extending downward from the blade plate before the osteotomy site is marked. The inner blade mark comes out just above the lesser trochanter, thus assuring a high osteotomy. The osteotomy is then completed and rotation is accomplished, as well as fixation. A window is then made in front of the trochanter segment just distal to the fracture line. Through this window the sclerotic bone and fibrous tissue are removed from the fracture line. Curettement up into the head allows numerous chips of cancellous bone from the ilium to be impacted well across the fracture line, and one large graft is fixed into position to give added stability. The window can be replaced. Internal rotation is maintained postoperatively for six to eight weeks; then the patient is allowed up on crutches with no weight bearing for a period of months. X-ray progress studies show when this protection may be discontinued when there is evidence of thorough revascularization of the head.

With this procedure the author reports solid union in nine of ten cases. The one case in which union had not occurred resulted in a good, stable, functioning hip. There was roentgenographic evidence that healthy bone had formed in the head of the femur in which there was increased density, indicating reestablishment of circulation to the head. This fact, and other observations, has led to considerable difference of opinion as to what constitutes a "dead" head and as to the procedure that may be effective in the presence of roentgenographic evidence of aseptic necrosis. The author cautions that it would seem wise to assume a cautious and conservative attitude toward removal of "dead" heads, since there is a possibility for regeneration of bone in a large proportion of these cases. The combined operation he advocates has resulted in regeneration and revascularization of bone in roentgenologically "dead" heads in cases of two and three years duration.

The author suggests that reevaluation of these fractures by a mechanical analysis in relation to impaction and position of the fracture in relation to the interruption of blood supply may furnish an approach toward classification and prognosis of cases at the time the fracture occurs. In cases in which preliminary study indicates that impaction is unlikely to occur with simple nailing, some type of operation designed to bring about impaction and stability of the fracture might be performed as a primary procedure. The author would favor the controlled osteotomy to correct this if this were used, in properly selected cases.

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SECTION 10

TUMORS OF BONE AND SOFT TISSUE

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Tumors in General: Diagnosis, Treatment, Classification, etc.

Phemister (1) reports 23 cases of sarcoma with 7 long term survivals, treated by resection and bone transplantation. Only one of these cases was an osteogenic sarcoma, however. Coley, et al (2) advocate a less radical procedure than amputation and suggest the role of less radical amputation if indicated, substituting a high thigh for a hip disarticulation, etc. They suggest segmental resection and partial resections of the bone which is involved.

De Los Santos (3) gave a discussion of the most common malignant tumors of bones, their recognition and treatment as seen in the National Orthopedic Hospital, stressing early diagnosis and radical treatment. He also discussed the metastatic tumors and hormonal therapy.

Lawrence (4) in discussing isotopes in neoplastic disease, says the greatest contribution of their use will be in tracer studies of metabolism and its therapeutic value is still not understood too well.

Hatcher (5,6) recommends regional resection of tumor and conservation of function when possible. He states that progress is about as good with amputation. He does advocate an amputation of leg in highly malignant tumors.

Brailsford (7,8) decries the widespread belief in the infallibility of histological examination of biopsy material and believes the radiological features are sufficient for the majority of diagnoses.

Wheelock (9) reviews the pathology and classifies the bone tumors on a histologic basis. He believes the pathologic basis for treatment should be used with the objective of curability with least impairment of function.

Holmes, et al (10) gave a study of the incidence in 16,363 roentgenograms of bone with a finding of 106 bone tumors or 0.63%. Of these there were 35 exostoses and solitary cysts, 4 multiple myeloma, 3 osteogenic sarcoma, 1 Ewings tumor and 1 endothelioma, 52 metastatic tumors from breast and prostate cancer, and 10 soft tissue tumor with involvement of bone by direct extension.

Guri (11) gives a review of literature of Tumors of the Vertebral Column, both of the primary type and those of metastases from other tumors.

Joynt and Ortved (12) report a case of accidental operative transplantation of a benign giant cell tumor to the ilium which was made as a donor site for the filling of the defect made by curettage of the original lesion in a tibia.

Malignant Osteogenic Tumors

Osteogenic Sarcoma.-Ackerman (13) reports two cases of multiple osteogenic sarcoma. The evidence was not in favor, however, of multiple primary origin but emphasizes that multiple bone lesions are not always due to non-osteogenic origin.

Moore (14) reports a case of periosteal osteogenic sarcoma in a 15 year old boy following trauma. Trauma occurred 3 years previously. (Ed. note: Although it was thought for years that trauma was only coincidental in these cases, there is increasing evidence that it does play a part.)

A case of an enormous tumor of the shoulder treated palliatively with shoulder girdle amputation was presented by Cornell and Jones (15).

Warren (16) discusses a case of Paget's disease of the skull with sarcomatous degeneration in a 60 year old woman. The average age is 66 years with the disease present for 12 years.

Howard (17) believes osteogenic sarcoma should be treated by x-ray rather than radical surgery.

Griswold (18) reports a case of osteochondrosarcoma of the sternum treated by resection and replacement with a tantalum plate which was unsuccessful because of trauma and bleeding on respiratory movements.

Ewing's Sarcoma.-Endothelioma of Bone (Ewing's sarcoma) by Coley, et al (19) gives an excellent discussion of this tumor based on the author's conclusions on 73 cases. Pain is almost always the first symptom, in an age group of from 5 to 25 years which affects males in a ratio of 2 to 1. They bring out the similarity of the process to an infectious or inflammatory process, its early metastasis, and uniformly poor end results. They list a survival rate of 4.1% for five years with palliation as the only treatment available, this being best achieved by roentgen therapy.

Mabrey (20) gave a case report of a case diagnosed clinically as a chondrosarcoma in a 19 year old male which was treated by resection of the lower one-half of the sacrum and entire coccyx and proved to be an endothelioma on pathological study.

Metastatic Bone Tumors

Shockman and Harrison (21) in a discussion on Occult Bone Metastases believe that the methods of clinical and radiological surveys do not demonstrate many lesions, and that the skeleton often shows many on careful study by hand lens at post-mortem followed by microscopy. The marrow is often filled and the bony architecture not altered.

Coles and Schulz (22) reviewed 288 cases of malignant lymphoma over a 10 year period with 13% showing bone involvement. Bone involvement did not affect the prognosis.

Silverman (23) presented a study of clinical and roentgenographic observation in 103 infants and children with skeletal lesions in Leukemia. He stressed the value of a bone biopsy.

Colson and Willcox (24) report 3 cases of bronchiogenic cancer metastasizing to phalanges of hand, toe and a metatarsal.

Smedal and Salzman (25) present the data on 100 consecutive cases of treatment of metastatic bone tumors. They believe x-ray therapy should be given only when symptoms are present, and is the best palliative treatment available. Hormonal therapy was effective in the bone metastasis from carcinoma of prostate. Limited use of radioactive substance, radioactive iodine and phosphorus was reported.

Benign Osteogenic Tumors

Osteoid Osteoma.- Lapidus and Wilson (26) presented 3 cases of osteoid osteoma with a brief discussion of the clinical characteristics. They believe Roentgen control or surgery is indicated.

Osteoma.- Brunner and Spiesman' (27) report 4 cases of osteoma involving frontal and ethmoid sinuses. They should be surgically removed if any tendency to expand exists. The mixed type is most frequent, spongy core and compact cortex.

Ossifying Fibroma of Bone.- Shaefer (28) reports a case of adamantinoma of the mandible treated after recurrence with resection and replacement with rib.

Exostoses.- (Ollier's Disease).- Dickson and Cohen (29) reported a case of hereditary deforming chondrodysplasia in a 22 month old child giving the family background.

Fun-Yong Khoo, et al (30) reported 7 cases in Chinese subjects. They believe that it is a disease also of the flat bones. Treatment only as symptoms arise or permit for the surgical removal of those offenders.

Giant Cell Tumors.- Roy (31) reports a case of benign giant cell tumor of the sacrum in a 20 year old male, treated by x-ray with later curettage. The areas recalcified with no return of symptoms.

Chikianco (32) reports a benign giant cell tumor in the tibia and fibula of a 10 year old boy with 6 year follow-up following x-ray therapy.

Bone Cysts and Fibrous Dysplasia

Fibrous Dysplasia, Polyostotic and Monostotic.- Sante (33) correlated the x-ray pathology and clinical findings in polyostotic fibrous dysplasia and compared it to Ollier's Disease as well as other diseases presenting cystic changes in bone. Clinically fibrous dysplasia of bone is insidious in onset, and has extra-skeletal lesions such as abnormal patches of skin

pigmentation and sexual precocity. The x-ray findings show tiny cyst-like areas in cortex, shell-like thinning of cortex, spontaneous fractures, no periosteal elevation, no general osteoporosis but a sclerosis of involved bone, widening and elongation of the shaft and a tendency to unicameral involvement. Brooke (34) confirms the discussion of Sante. In his differential diagnosis he believes the condition to be most often confused with osteitis fibrosa cystica.

Wooley and Alpern (35) report a case of a 3 year old negro child with typical findings. Bingold (36) reports a case and discusses the clinical, pathological and x-ray diagnosis. Hammond and Sponsel (37) report a case treated with bone graft from mother. They revealed that 39 cases were reported in the literature up to 1945.

Schlesinger (38) reports a case of monostotic fibrous dysplasia of the tibia in a 3 year old male who had an amputation 5 years later after numerous operative procedures for pseudarthrosis.

Ayers (39) reports a case involving a rib and claims that this is the most common location for a single bone involvement. Excision is the treatment of choice. Mammel (40) compares localized fibrous dysplasia and ossifying fibroma and believes they can be considered to be variants of the same process.

A case of solitary bone cyst of the os calcis was reported by Hundley (41). He states that only 4 cases were reported in the literature. (Ed. note: This lesion is much more common than this would indicate.)

Heublein and Baird (42) report a cyst of the ilium as an uncommon site.

Leslie and Stenhouse (43) report a case of localized osteitis fibrosa of the skull.

Synovioma

Harris (44) presents 3 cases of synovioma, in the ankle region, calf muscles, and adductor region of the thigh. 2 cases survived amputation, but the case involving the adductor thigh muscles succumbed 7 months postoperatively.

Kessel (45) reports a 38 year old female with a synovioma of the region of the lateral malleolus. Below knee amputation was done but check x-rays have shown metastases.

Warren (46) presents a case of a 31 year old female with a fixed subcutaneous mass in the sole of the foot, diagnosed synovial sarcoma although not involving any joint. Radical resection is indicated including removal of regional lymph nodes.

Johnson (47) differentiates between synovioma and synovial fibrosarcoma. Synoviomas contain endothelium-lined cavities, metastasize to regional lymph glands, are radio-sensitive; synovial fibrosarcoma do not and in addition often contain irregular calcific deposits.

Multiple Myeloma

Scott (48) reviewed the clinical and pathological aspects of multiple myeloma with presentation of 5 cases. The average age was 55. Secondary anemia was a constant finding with pain the most frequent symptom.

Langley (49) reports 7 cases in an age range from 53 to 69. One case was treated with stilbamidine with relief of pain and disappearance of the Bence-Jones proteinuria.

Baker and Casterline (50) report 4 cases treated with stilbamidine. They felt that no effect was received.

Snapper (51) says that 80% of cases are partially relieved of pain by stilbamidine and that the drug appears to have an affinity for the abnormal nucleoproteins of the myeloma cells.

Cope and Wyman (52) report a case with normal serum protein in a 72 year old woman.

At the CPC of Medical College of Alabama a case of multiple myeloma was presented and the findings outlined by Stokes, et al, (53).

Spitzer and Price (54) report a solitary myeloma of the mandible in a 34 year old male and Chesterman (55) wrote on the follow-up of solitary plasmacytoma of the long bones, presenting 4 cases treated by surgery with 4 to 12 year survival, one with amputation and others with curettage and bone grafting.

Lumb (56) reports a case of solitary plasmacytoma of sacrum only found at autopsy after it was suggested by the clinical course of the disease.

Eosinophilic Granuloma

Ponseti (57) presents 8 cases of bone lesions, in eosinophilic granuloma, Hand-Schüller-Christian Disease and Letterer-Siwe Disease, to show that they represent forms of the same pathological process. He believes that the solitary eosinophilic granuloma is the mildest form of this group of diseases. In the case where there is involvement of other organs besides bones it is convenient to group them under a common heading with Hand-Schüller-Christian Disease and Letterer-Siwe Disease. The cause may be a low grade infection. X-ray therapy has a favorable influence on the lesions. The older the patient the more favorable the prognosis.

Baker and Fisher (58) report 4 cases of eosinophilic granuloma of the skull with a 5 year follow-up. They report some cases of spontaneous resolution in their review of the literature.

W. J. Baker, et al (59) support the relationship of the disease to Hand-Schüller-Christian's Disease. They emphasize that all symptoms are due to local lesion. A typical case in a 39 year old male was reported.

Conran, (60), Schroff, (61), and Kauffman (62) reported cases involving the jaws.

Kendrick and Woodruff (63) report a case of eosinophilic granuloma involving the scapula, a portion of a rib and areas of a dorsal vertebra in a 12 week old white female. There was an associated cutaneous lesion simulating an impetigenous eruption over the trunk. Diagnosis was confirmed by biopsy of scapula. All lesions responded to radiation therapy with complete resolution of the osseous lesion.

Weaver (64) reports a case in a 3½ month infant.

Schuknecht and Perlman (65) bring out that a lesion may manifest itself first by erosion or perforation into an external auditory canal or into sinuses, or even a facial nerve paralysis first. The lateral supraorbital region of frontal bone appears to be the site of predilection for solitary granulomata. If surgery is done without a positive diagnosis, it should be followed by irradiation.

Dill (66) reports a 5 year old child with onset as a mastoid involvement and later a parietal bone involvement.

Ackerman (67) reported a case with involvement of lung and diaphragm.

Love and Fashena (68) reported a case which first manifested itself as an eosinophilic granuloma and later as a Hand-Schüller-Christian Disease. Maurer and DeStefano (69) reported a case with rib involvement. Dickson (70) reports a case with diffuse pneumonia involvement of lung.

Sarcoidosis

Cameron (71) discusses the clinical aspects of Sarcoidosis and feels that it may be a tuberculosis of a fibrosing and non-caseating type. Cystic changes in bone occurs in 20% of cases usually in the heads of phalanges, metacarpals or metatarsals. "Diagnosis can only be made by histological exam. of involved tissues...." showing the epithelial tubercle.

Pautrier (72) discusses the most prominent etiologic factors and believes that tuberculosis or an unknown virus causes it. Freudenthal (73) gives the pros and cons for the tuberculous origin. Snapper (74) feels that it may be a separate entity.

Fischl and Freireich (75) report a case with fatality due to hemoptysis. Hurst (76) reports a case and suggests that superficial lymphadenopathy with unexplained pulmonary x-ray changes should always suggest it. The hand showed typical lesions.

Reeves, et al (77) review the literature briefly and report 13 cases in children, most of which had no bone involvement.

Ustvedt (78) gave autopsy findings in 3 cases. They all had hilar adenopathy with fibrotic strands containing numerous nodules of epithelial cells,

fibroblasts and Langhan's cells without caseation or necrosis. One case died of hemoptysis from cavitation in lung. He suggests that the tuberculous theory is due to chance only in that it was found in only 18% of cases autopsied.

Cartilaginous Tumors

Shellito and Dockerty (79) studied 42 cases of cartilaginous tumors of the hand. The enchondromata were 3 times more prevalent than ecchondromata. Their recommended treatment was conservative surgery.

Miscellaneous

Metabolic Diseases.- Short (80) discusses osteomalacia associated with steatorrhea. There was no diarrhea, nor inadequate diet in one case of a 50 year old white female reported. A study showed a high fat residue in her stools with a serum calcium and phosphorous below normal. A pancreatic deficiency is thought to be the cause.

Miscellaneous.- Hauser and Constant (81) report a case of skeletal hemangioendothelioma. The authors believe that, though rare, it must be considered in all skeletal lesions which are cystic, trabeculated, invading soft parts. They recommend surgical treatment.

Hatcher (82) discusses extraskeletal ossification simulating sarcoma. He does not believe that the term myositis ossificans and calcifying hematoma are appropriate to describe heterotrophic ossifications about joints or in muscles. The young reactive fibroblastic tissue replacing damaged muscle is considered responsible for the formation of bone and cartilage. Immature bone trabeculae later form in the ossifying mass. The mass later may surround or attach to bone and is not a projection of the bone itself.

Jaffe and Lichtenstein (83) report and describe 8 cases of a distinctive benign tumor of bone which they name chondromyxoid fibroma. These tumors have probably been reported previously as enchondroma and myxoma or their cancerous counterparts. They interpret the lesion as a peculiarly differentiated connective tissue tumor, exhibiting in the course of its evolution, certain chondroid and also myxoid traits which hallmark the lesion cytologically. It is composed of cells lying loosely in a myxoid intercellular matrix, which as the tumor matures, may undergo substantial collagenization. The tissue in any particular specimen may also come to simulate cartilage tumor tissue in some fields, and its gross appearance, likewise, bears a certain resemblance to cartilage. The presence of smaller or larger numbers of tumor cells exhibiting nuclear atypism may cause the lesion to appear more ominous than it is known to be, explaining why it may come to be overdiagnosed as a malignant tumor, particularly as chondrosarcoma.

The lesion was usually found in the femur, and tibia, in the metaphyseal area adjacent to the knee joint. In these bones the lesion did not extend across the entire width of the metaphysis, but did erode and even substantially destroy the local cortex, causing bone contour to become bulged. Where

a demarcating cortical shell was absent, it was evident that the tumor was still contained by the periosteum and the overlying parosteal connective tissue. On its inner surface the tumor is usually bordered by a zone of sclerosed bone.

Most of the patients were adolescents or young adults. The lesion evolves slowly, it is apparently benign and does not tend to recur after curettage. Its recognition is of importance in that pathologically it may readily be mistaken for sarcoma and, as such, treated more radically than is necessary.

Schorr, et al (84) report a case of chondroma of lumbar vertebra mistaken for a tuberculous spondylitis until excised and examined histologically.

Ross (85) reports 2 cases, a sacro-coccygeal chondroma and a metastatic carcinoma to sacrum. In his review of sacral and presacral tumors he found 1 case in 46,183 admissions.

Hawk and Hopkins (86) discuss 25 cases of malignant tumors of the soft tissues of the extremities. Fibrosarcoma was present in 19 with 1 each of neurogenic sarcoma, synovial sarcoma, angiosarcoma, rhabdomyosarcoma and 2 myosarcomata. Mortality rate was 65%, with 30% being without disease due to amputation or excision and 5% living with disease. Excision either by amputation or local if possible was favored.

Reissman (87) gives a brief discussion of Schüller-Christian's Disease and raises the question of whether there is a differentiation between lipoid granulomatosis of the bone and Schüller-Christian's Disease.

Potter and Coverstone (88) report a case of a chondrodystrophic infant born to dwarfed parents with the same condition. Only two cases have been reported before with both parents and child having this condition.

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SECTION 11

CONDITIONS INVOLVING THE LOWER PART OF THE BACK

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From the number of papers written on subjects related to the low back we must conclude that low back conditions are among the most important current problems with which the orthopedic surgeon is called upon to diagnose and treat. The intervertebral disc syndrome was the most discussed subject of all low back conditions.

Jones (1) gives an interesting review of the highlights of the changing trends in the treatment of backache by eminent authorities. A discussion of the syndrome of the low spinal disc includes the concept of injury as an etiological factor even in normal backs without lumbar lordosis. Faulty posture which causes even normal activity to become trauma is considered an etiological cause.

Early symptoms are located in the lower back but after recurring attacks the pain is referred to the hip or the mid-gluteal region followed by pain down the leg. The pain does not necessarily follow the distribution of the sciatic nerve but picks out the areas supplied by the spinal nerve root. The overlapping of nerve roots makes it necessary to have two adjacent roots affected to produce anesthesia while involvement of one will effect paresthesia. Later in the development of the disc syndrome the density may be constant and the remission incomplete.

Treatment should include continuous rest in bed during the acute period without active physical therapy. Additional rest of the lower anatomical part of the low back is provided by corsets, braces and casts. Heat and massage are recommended when accompanied by relief of pain. Manipulation may offer some benefit in patients undergoing exacerbation and remissions but should not be utilized when irreducible protrusion of the disc is present. Novocaine injections are not utilized because of the lack of good evidence and information as to their benefit and curative value. Medication for relief of acute pain is imperative. In the choice of treatment patients are divided into three classes of mild, moderate and severe and treatment selected to fit the severity of the case. Conservative care is indicated until incapacity is clearly demonstrated, but surgery should not be unnecessarily deferred. Classification of causes of back pain are listed below.

I. POSTURAL STRAIN (Chronic drag of gravity)

II. TRAUMA

1. Injury to soft tissues
2. Injury to vertebrae and joints
3. Injury to intervertebral discs

III. INFECTION

1. Spondylitis deformans
2. Fibrositis and myositis
3. Actinomycosis
4. Blastomycosis
5. Brucella abortus
6. Osteomyelitis
 - A. Pyogenic organism
 - B. Typhoid
7. Epidural abscess
8. Neisserian involvement

IV. CATCH ALL CLASS

(Growth disturbances, metabolic, endocrine, senescent and neurotropic)

1. Osteochondritis (Calvé)
2. Adolescent epiphysitis (Scheuermann)
3. Senile epiphysitis and osteoporosis
4. Neuropathic joints of tabes and syringomyelia
5. Parathyroid tumor
6. Paget's disease
7. Gout

V. CONGENITAL ANOMALIES

1. Defects of isthmus (most important)
 - A. Spondylolisthesis
 - B. Spondylosis
2. Spina bifida (occulta)
3. Asymmetrical lumbosacral facets
4. Sacralization transverse processes
5. Lumbarization transverse processes
6. Extra or deficient vertebrae
7. Wedged vertebrae

VI. NEOPLASTIC

1. Benign
 - A. Osteoma and osteochondroma
 - B. Giant cell tumor (may be malignant)
 - C. Hemangioma
 - D. Eosinophilic granuloma
2. Malignant
 - A. Primary
 - a. Sarcoma and osteogenic sarcoma
 - b. Lymphoblastoma
 - c. Multiple myeloma
 - B. Secondary (metastatic)
 - a. Carcinoma of breast
 - b. Hypernephroma
 - c. Thyroid
 - d. Prostatic carcinoma
3. Tumors of the spinal cord, its meninges, roots and the filum terminale

VII. VASCULAR

1. Aneurysm

VIII. PSYCHOGENIC

1. Hysteria
2. Malingering
3. Psychoneurosis

Butler (2) presents a review of the role of the general surgeon in the management of low back pain, including history taken, physical examination performed, and general causes of low back pain along with differential diagnosis and treatment. Included in the general surgical causes of low back pain, attention is invited to the incidence of this complaint in those patients suffering from carcinoma of the rectum, diverticulitis, bowel obstruction, gastrojejunal ulcer, advanced ulcerative colitis, Meckel's diverticulum, intra and extra peritoneal enlarged nodes, abscesses, cysts and tumors, as well as metastatic malignancy and strangulated inguinal hernia. In differentiating patients with backache referred from the above conditions, it is well to remember that patients with surgical lesions of the esophagus, stomach, duodenum, biliary tract, pancreas and diaphragm have referred pain to the back, but at a higher level than other general surgical conditions of the low abdomen.

The usual conservative measures of treatment of patients presenting themselves with complaints of backache are followed. Only those patients suffering from a mild degree of low back pain are treated as ambulatory patients; the rest are given bed rest. Those patients with marked pain and spasm of the low back, particularly those with sciatic scoliosis are routinely hospitalized. Unless satisfactory remission of pain and tenderness is accomplished in approximately seven to ten days, the patient's spine may be gently manipulated. Manipulation is performed with or without anesthesia, depending upon the degree of relaxation desired. Manipulation is not performed in cases with marked arthritis, spondylolisthesis or ruptured intervertebral discs. While hospitalized these patients are treated intensively but treatment is not terminated with discharge from the hospital and a home program of treatment is outlined, including physiotherapy, and strengthening exercises for the back abdominal musculature. Belts, braces and casts are recommended, but caution should be followed to prevent overuse.

The major proportion of patients suffering from low back pain, with or without sciatica, will recover under a conservative plan of treatment. Where conservative treatment is not indicated, or has not been successful in a reasonable length of time, the patient should be referred to an orthopedist or neurosurgeon for more specialized diagnosis and treatment. It must be remembered that low back pain may be the presenting symptom in an entirely unsuspected malignant disease of the rectum, sigmoid colon and other pelvic structures. Any patient with unexplained low back pain who has not had this possibility fully explored has not been completely examined or worked up.

King (3) discusses back pain from the gynecological standpoint. He states the exact mechanism by which pain is produced and the anatomical pathways along which the afferent stimuli travel in those patients having

backache in association with gynecological problems is not completely understood. Greenhill states that "the backache in less than half of all women is due to disturbances in the pelvic organs or to abnormalities in the kidneys." It is likewise generally held that backache of pelvic origin is fairly definitely localized to the sacral area and that pain above this region is not due to pelvic pathology.

Back pain due to abnormalities of position of pelvic organs is not fully understood. A uterus that is normal in size, shape and mobility but which has assumed a retroposition practically never gives rise to back pain. The recognition of this fact has led into decreased incidence in uterine suspension operations among competent gynecologists. If symptomatic relief is obtained with the uterus held in antiflexed position and if the retroposition and pain return when the pessary is removed, the possibility of operative measures can be considered, but under no other circumstances. A relaxed vaginal introitus occasionally gives rise to backache as a chief complaint, but this is uncommon. Usually the complaint of backache in these patients is not the chief complaint. When it is the predominant symptom one should be very cautious in promising relief following the correction of the relaxation.

Back pain due to inflammatory reaction in the pelvic lymphatics, particularly along the course of the uterosacral ligaments, as evidenced by a thickening and induration of these structures, accompanied by tenderness and pain, can often be relieved by satisfactory treatment of the inflammatory condition. Occasionally amputation of the infected cervix will be necessary before a cure can be obtained. Patients suffering with inflammatory involvement of the upper generative tract frequently respond to suitable therapy. This can be considered as a differential diagnostic point between pelvic inflammatory disease and acute appendicitis. Acute appendicitis almost never has backache among the complaints of the patient. Backache is a common symptom in patients suffering with chronic inflammatory disease of the pelvic organs, particularly in those patients where adhesions are present between the posterior parietal peritoneum and the adnexa or uterus.

Back pain due to tumors and cysts is surprisingly uncommon. The pull or stretching of the pedicle of an ovarian cyst will occasionally be associated with backache. Myomatous tumors of the uterus practically never cause back pain unless there is associated pelvic inflammatory condition with the presence of adhesions.

Back pain due to endometriosis is found in those patients with involvement of the posterior surface of the uterus and the cul-de-sac, accompanied by dense adhesions running to the rectum and the posterior parietal peritoneum.

Back pain in association with premenstrual tension and/or dysmenorrhea is probably due to congestion as a result of an increased pelvic circulation and associated edema of the pelvic tissues. These patients are occasionally helped by the use of ammonium chloride, testosterone and progesterone.

Back pain due to psychogenic states is a difficult decision to reach and should not be determined until all gynecological, orthopedic, urological and neurological causes have been ruled out. The response of these patients to treatment will depend upon the duration and degree of the fixation, the etiology of the mental state, and the ability of the investigator. Psychiatric help should be obtained in the management of these cases when it seems indicated.

Platt (4) gives a historical review of the stages through which our present knowledge of the pathogenesis of the backache-sciatica syndrome has been reached. Diagnosis of the cause of sciatica, can be approached by the recognition of five main groups: (1) Pelvic visceral disease. (2) Bony lesions of the lumbar spine, pelvis and femora, i.e., destructive lesions, inflammatory or neoplastic. (3) Joint lesions of the spine, pelvis and hips. In this group the protruded disc had displaced sacroiliac strain and vertebral arthritis as the dominant lesion, but these two were still real lesions and sciatic pain was common in osteoarthritis of the hip joint. (4) Central nervous lesions proper, e.g., cauda equina tumors. (5) Pseudosciatica; fibrositis of the fascial, ligamentous and muscular structures in the lumbar region, buttocks and thighs. This type of "sciatica" was numerically important; fibromyositis might of course cloak an underlying arthritis of the lumbar spine in which degenerative changes were likely to be present in the intervertebral discs.

In comment, Professor Geoffrey Jefferson agreed that a single brief attack of sciatica might conceivably be due to neuritis, but could not prove the point, and believed this etiological agent to be a rare disease. A survey collected by letter interview revealed two-thirds of a group of twenty-six unoperated patients to have continued attacks of pain while three had been badly handicapped. This survey was in line with the Scandinavian reviews of close to 500 patients and indicated little support to the contention that sciatica was commonly a transient and unimportant disorder. Relapses in unoperated cases could be accounted for in three ways: (1) Because there is from time to time a sudden further small protrusion of disc tissue. (2) Because the prolapsed disc remained unchanged, there are recurrent episodes of edema and congestion. (3) Because tension excited by the hernia is intermittent, the disc popping in and out.

This latter process was difficult to believe since the hernia probably caused pain by tension rather than pressure on the nerve root. Professor Jefferson said that 82% of 130 cases operated upon by himself or his assistants had obtained complete relief of pain, or had only a small amount of residual pain. Results of this order were considered good and surgery indicated. The relation between disc herniation and sciatica was now firmly established, but the history and clinical signs of cases with a disc lesion were often identical with those where there was no such lesion, and the differences must be discovered before improved results were to be obtained.

Ytreheus (5) presents an exhaustive survey of 256 patients, including 151 men and 106 women whose sciatica was managed conservatively. As Lasegue's sign is the cardinal symptom in sciatica, the patients were

divided into three groups as follows: Group I: Positive Lasegue's at 60° or more: 50 patients (20%); Group II: Positive Lasegue's at 30° to 60°: 134 patients (55%); Group III: Positive Lasegue's at 30° or less: 72 patients (25%).

The principle adopted for treatment in this series of cases has been absolute confinement to bed until the patient is free from pain when at rest and until positive Lasegue is not attained before at about 60°. Analgesics and salicylates have been employed in association with massage and x-ray has been utilized in those patients who demonstrated radiographically spondylitis deformans. Injection treatment and brace have been employed only in a couple of the cases of this series. The follow-up investigation of these patients was made by means of inquiry form (in which special stress was laid on particulars respecting subjective symptoms and disability) and 140 patients of this group were personally examined by the author. In 107 cases the information submitted regarding subsequent incapacity for work was checked by inquiries addressed to the sick-insurance offices. The average time spent in hospital was 37.2 days and the average number of days illness was 97.3. Forty-seven percent were free from symptoms when discharged from the hospital. Material is divided into three groups according to results of the Lasegue test and the three groups differ distinctly with reference to the length of time spent in the hospital and duration of the period of disability. Seven of the patients were operated for sciatica. Of the remaining 213 patients 33.8% were found on re-examination to be fully capable of work and free from pain, 37% were fully fit for work but still had some subjective troubles, and 26.8% had more or less reduced ability to work on account of sciatica.. None of the patients re-examined were quite incapacitated for work from the disease and only 3.3% had been obliged to seek lighter employment. In 2.4% the capacity for work was reduced owing to other causes. Thirty percent of the patients have had recurrences which in 10.8% of the cases necessitated readmission to the hospital. In general, the more positive the Lasegue's sign, the longer the duration of illness, the poorer the results and the more probable the readmission to the hospital.

In conclusion the author briefly discusses the indications for operative treatment which are primarily grave neurological defects, intolerable pain and failure to respond to conservative treatment. If after three months the patient does not show satisfactory progress and has pain which is incapacitating, the case should be reviewed for consideration of surgery. No patient should be subjected to an operation before he has undergone careful medical treatment in the hospital.

Boysen (6) surveys the material of 431 patients suffering from sciatica from the three medical departments of Oslo Municipal Hospital in the period between 1938 and 1944. The material consists of 220 men and 211 women. The disease affects the right sciatic nerve just as frequently as the left one. Fourteen percent had bilateral pain. Most of the patients were between 26 and 50 years of age, with a distinct maximum of the age group, 36 to 40 years. The average duration of hospital stay is twenty-one days, the patient having reported sick an average of three weeks before admitted and five weeks after discharge. Lumbar puncture, neurological examination and x-ray examination of the lumbar column, pelvis and both hip

joints has been performed on a great number of these patients. The results of these examinations; and especially their prognostic value, is discussed. Two hundred seventy-seven patients are control-examined. Of these 183 are personally examined by the author. The time of observation is from two to eight and one-half years. Substantial weight is laid on estimating the patient's capacity of work, the obtained relief of symptoms and continuation of pains with possible relapse resulting in a renewed confinement to bed or a further stay in hospital. Eighty-six and five-tenths percent of the patients are in full work, 11.5% have had to take lighter work and 0.7% are completely unfit for work. Twenty-one and one-tenth percent are free from symptoms, while 78.8% have continued pains in a greater or lesser degree and 30% of the 277 patients have had a relapse. After the age of 46 years relapse is rare. One cannot draw any prognostic conclusions on the basis of the length of anamnesis, duration of stay in hospital, the result of the examination of the spinal fluid, x-ray examination or the neurological examination. The conservative treatment has been: absolute confinement to bed, analgesics, local warmth and massage. In the case of spondylosis x-ray treatment was applied. Sixteen patients were operated on of which ten were free of symptoms after the operation, two have continued pain and two have been operated on too recently to include in this survey of observations. In the cases where there are strong persevering pain and considerable neurological defects, operation is definitely indicated, otherwise the subjective inconvenience and reduction of the capacity of work must be a deciding factor. A final standpoint as to the time in the development of the disease when the patient ought to be subjected to an operation can only be taken when a sufficiently extensive material of operated patients, where substantial weight is laid on the control-examination with regard to the capacity of work and continuation of the pain after operation, is available.

Between 1936 and 1945 most of the cases of sciatic pain treated at Princess Elizabeth Orthopaedic Hospital were treated primarily by the use of relative immobilization of a plaster jacket, and this paper by Durbin (7) is a summary of the results. Included in this survey are only those patients with positive neurological signs such as absent ankle jerks, diminished ankle jerks, absent knee jerks, sensory disturbance, muscle wasting etc. Two hundred twenty-five patients with these signs were treated but it was not possible to trace 78 of these patients. Of the 147 who were traced, including 82 men and 65 women, 123 were treated by relative immobilization in a plaster jacket from two inches below the nipple line to the symphysis pubis anteriorly and to the lower part of the sacrum posteriorly, and kept in this position for two to three months. The plaster jacket was applied with head traction in order to steady the spine. In the majority of cases ambulation was possible as soon as the plaster was dry, and pain was much relieved within one or two days. If pain persisted the patient was kept in bed and skin traction was applied to the leg. The application of a plaster corset is better than simple recumbency in bed because it affords more complete protection of the lumbar spine, thus allowing more complete relief of nerve root irritation, and encouraging reduction of the prolapsed intervertebral disc. Simple bed rest over a period of many weeks offers less control of spinal movement, delays rehabilitation of the patient and involves wastage of hospital beds.

Of the 123 patients treated 43 were cured (34%), 35 were relieved (29%), and 45 were not relieved (37%).

It is clearly shown that relief or cure by simple plaster immobilization becomes less as the duration of symptoms increases: The more complete the neurological signs, the less is the prospect of relief by simple immobilization. Of 21 patients who before treatment displayed all three signs; diminished or absent ankle jerk, hypesthesia and wasting of the calf, only 14% were cured, 48% were relieved and 38% were not relieved. It is evident that when an ankle jerk is once lost it is unlikely to return, but that diminution of an ankle jerk often disappears when symptoms are relieved. Furthermore, sensory disturbances due to nerve root pressure persist in the majority of cases.

In a detailed discussion of fibrositis Traeger (8) calls attention to the confusion and controversy regarding this disease entity which he believes is due to the following factors: (1) Diagnosis and classification are difficult because of the paucity of objective findings, such as laboratory and x-ray evidence, absence of temperature, swelling and inflammation. (2) Because of the nature of the disease, biopsies are rarely obtained and the pathology of this disease entity, if indeed it can be so described, is obscure. (3) No definite etiology has been proved. (4) The disease is usually self-limited. Fibrositis, excluding the traumatic type, may be classified into three groups: (1) Primary fibrositis, a disease entity that exists independently and is not accompanied by any other definite disease; (2) secondary fibrositis, a disease entity which occurs coincidentally with other diseases, such as gonorrhea, infectious fevers, gout, rheumatoid arthritis or osteoarthritis, rheumatic fever and trauma; (3) senile fibrositis, in involvement of the fibrous tissues of the body as a natural accompaniment of the aging process. In this chapter primary fibrositis only is of clinical importance. In secondary fibrositis the diagnosis and treatment are obviously directed to the accompanying disease.

History: Fibrositis was originally described by Jaccoud but the present designation dates from the introduction of the term by Gowers in 1904, and by Stockman in 1933 and 1934.

Etiology: The etiology is unknown.

Diagnosis: Diagnosis is made by a process of exclusion. There is no external evidence of joint pathology. Roentgen examination of the joints is negative. There are no significant constitutional reactions, such as fever, anemia or loss of weight. There are no abnormal laboratory findings.

Symptomatology: In the acute variety, the diagnosis is made chiefly on the presence of local muscle tenderness, pain and spasm, and the absence of any other objective findings. In the chronic forms, diagnosis is made from the subjective findings of stiffness and aching of the muscles, joints and periarticular regions, and from the presence of the so-called "jelling phenomenon", which is a particular sort of stiffness that is alleviated by moderate exercise and aggravated by over exertion. There

is usually an exacerbation of symptoms by cold and damp weather and a diminution of symptoms during warm or dry weather.

The differential diagnosis between fibrositis and rheumatoid arthritis is reflected in the tabulation listed below:

DIFFERENTIAL DIAGNOSIS

<u>Fibrositis</u>	<u>Rheumatoid Arthritis</u>
Limited to a definite area	Polyarticular involvement as a rule
Tenderness a variable factor	Tenderness frequently outstanding symptom
Presence of stiffness or "jelling phenomenon", which disappears quickly after exercise or movement. Very frequently the first symptom the patient with fibrositis complains of is this "jelling" or stiffness of the joints after long periods of rest, such as sitting in a theater seat, playing bridge or on arising in the morning.	Stiffness persisting after motion or exercise
Muscular atrophy rare	Muscular atrophy quite common
Synovial exudate never found	Synovial exudate a frequent finding
Pain elicited only on extremes of motion or any type of forced movement that produces tension of the capsule	Pain on motion of affected joint a characteristic symptom
Pain frequently relieved after moderate exercise	Pain increased by motion or exercise or weight-bearing
Frequent remissions	Remissions uncommon
Systemic manifestations uncommon	Systemic manifestations comprising slight rise of temperature, loss of weight, loss of appetite, secondary anemia and low blood pressure
Slight capsular thickening possibly present	Capsular thickening possibly present
Elevated sedimentation rate and secondary anemia rare	High sedimentation rate and secondary anemia frequent

Differential Diagnosis (Cont'd)

Fibrositis

No roentgenologic evidence of bony involvement

Rheumatoid Arthritis

Roentgenologic evidence of bony pathology a rule

Pathology: The pathology of this disease has been inadequately studied because of the lack of biopsies. Authorities disagree on the pathological findings of the specimens that have been observed. A great deal more work needs to be done in this field before a differential diagnosis can be made on a pathological basis.

Distribution: The most common are intramuscular fibrositis and periarticular fibrositis. These two types may exist either separately or together in the same patient or they may alternate. Because fibrous tissue is present all over the body and therefore subject to the inflammatory process of this disease wherever situated, the anatomic distribution is widespread and may be classified according to location such as panniculitis, abdominal fibrositis, pectoral fibrositis, etc. Fibrositis in the underlying muscular material of the body is frequently termed myalgia, muscular rheumatism or myofascitis. Periarticular fibrositis involves only the periarticular structures of the joint, and is characterized by stiffness and soreness of the joints, usually after periods of prolonged rest and on arising in the morning. Periarticular fibrositis is frequently mistakenly diagnosed as atrophic arthritis, but again the diagnosis is made by exclusion. The distinction between tendinous fibrositis and tenosynovitis appears to be a rather finely drawn one, based purely on the extent of involvement.

Treatment: Treatment is divided into two main types, general and local. Rest is important in the relief of pain but should be confined only to the acute stages of the disease following which exercises should be gradually instituted. Cold and dampness seem to delay recovery and it may be necessary to create a complete change in the patient's environment. Medication is important only in the relief of pain while salicylates are the most efficacious drug if administered in adequate doses. Elimination of foci of infection is imperative. In cases in which fibrositis is generalized, cabinet baths or baths of hot epsom salts taken at home are effective in some cases, in association with gentle massage to stimulate the vasomotor system and the lymphatic circulation. Any form of physical therapy which produces relief should be utilized and treatment should not be confined to one or more measures. This will include diathermy, infrared radiation, hydrotherapy, paraffin baths, massage and exercise within the limits of pain. Favorable reports have been given to histamine by iontophoresis and by injection, as well as histamine cataphoresis. Deep x-ray therapy has been employed with promising results.

The orthopedic aspects of low back pain are outlined by Hamsa (9) with an interpretation of the significance of the positive signs observed. A discussion of some of the conservative measures of treatment of low

back pain such as correction of unequal leg length, diathermy, infrared radiation, hot packs and external support is included.

Posture is defined as the relationship of the center of gravity to the line of gravity. Normal posture is present when the relationship of the center of gravity to the line of gravity is comparable to that of the majority of individuals. Theoretically this line of gravity rises through or slightly anterior to the ankle, through the knee and hip joints, and then crossing the sacrolumbar, lumbodorsal and cervicodorsal sections of the spine. Under certain conditions as in pregnancy, obesity, muscular weakness or bone deficiency, the line of gravity is moved posterior to the sacroiliac joint and balance of the body is then possible only by excessive muscular effort or by accentuating the lumbar lordosis. This produces secondary increase in angle of pelvic inclination, a flexed position of the hips and dorsal kyphosis. This change of alignment alters the function of all systems of the body due to the secondary positions adopted by these organs, making possible the simulation of numerous organic changes including peripheral joint changes, but by far the most common condition found is strain of the low back structures.

In a general discussion of the subject of backache built around a tabulated outline of the problem Kleinberg (10) emphasizes the importance of a detailed history of the onset and course of illness, physical examination and pathological conditions in the back. One must bear in mind the numerous causes of backache most of which in a given case, can rapidly be eliminated by the history and examination. The final diagnosis depends upon the correlation of all the facts of the history and the evidence elicited by the physical examination, first of the special systems and then of the tissues of the back, supplemented by the required laboratory aids. Once the diagnosis of the cause of the backache has been established, the therapeutic program is readily outlined.

In an article on "Differential Diagnosis of Sciatic Pain" Stuck (11) tells us that pain is a subjective complaint and is variable in severity, character and location, thereby rendering interpretation difficult. The chronological history should be related to other symptoms and signs in order to aid in confirming the diagnosis.

Sciatic pain is a descriptive term used to localize pain traveling downward from the gluteal region into one or both legs. Fifteen types of sciatic pain of different causes are described with pertinent historical symptoms and signs to make possible a differential diagnosis. Some of the most common causes of sciatic pain as given by the author are:

- (1) Sciatic and back pain as a result of fatigue in patients who are not accustomed to strenuous work.
- (2) Hysteria or compensation neuroses.
- (3) Referred sciatic pain.
- (4) Spinal fracture.
- (5) Vascular disease, including Buerger's or Raynaud's, arteriosclerosis and varicose veins.
- (6) Sacroiliac disease.

- (7) Spinal cord tumors.
- (8) Gunshot wounds of the spine.
- (9) Hypertrophied ligamentum flavum.
- (10) Metastatic tumors of the spine, pelvis, hips and adjacent soft tissues.
- (11) Compression fracture of the lumbar spine.
- (12) Causalgia of the lumbosacral plexus.
- (13) Ruptured lumbar intervertebral disc. This is the most common cause of sciatic pain, unilateral in type.

The most significant recent single advance in the differential diagnosis of intervertebral disc has been the correction of the systemic dermatome sensory pattern for the lower extremity.

Moore (12) is of the opinion that: (A) Most cases of low back pain with or without radiation can be relieved. (B) All cases, especially the ones suspected of having disc protrusions should have a careful orthopedic study and analysis before surgery for the removal of a disc protrusion. (C) Most cases called "disc protrusion" do not have a protruded disc. Symptoms are due to mechanical irritation of the nerve roots. (D) Most cases of real disc protrusions are secondary to a mechanical or pathologic weakness of the spine and orthopedic treatment is indicated. (E) Most cases can be accurately diagnosed with a careful history, physical examination and x-ray studies of the spine. Disc protrusions can be differentiated from cases of mechanical root irritation and the site of the lesion can be localized with a high degree of accuracy without visualization of the spinal canal. (F) The primary cause of symptoms in most cases is mechanical weakness of the spine with increased lumbar lordosis. (G) Most cases can be treated with conservative orthopedic measures. (H) Of the cases that require surgical exploration, the fifth and fourth interspaces should be routinely explored. This should in most cases be followed by a type of spinal fusion that corrects lordosis at this segment and prevents the recurrence of nerve root irritation. (I) Fusions can be performed only when and if a practical technique has been developed that assures bony union in a high percentage of cases. (J) The decision for fusion can be made only at the time of surgical exploration.

Symptoms are due to narrowing of the posterior elements of the spine with pinching or irritation of tender soft tissues or mechanical compression or irritation of nerve roots at or about their emergence through the intervertebral canals. The causes of nerve root irritation are many. In infancy the spine is practically straight. In adolescence the lumbosacral angle is about 15 degrees to 18 degrees. In young adult life it normally may approximate 25 degrees to 35 degrees. From middle age and beyond it may increase from 45 degrees to almost 90 degrees depending upon its structure and the strain that has been imposed. It is common knowledge that few patients less than twenty years of age have ruptured discs. Presumably, this is due to the youthful position of the lumbosacral angle and the strength of the structure. If this strength and position could be maintained without degenerative changes, no symptoms would develop in later life. It is then logical that the treatment of low back conditions where lordosis is exaggerated and the integrity of the structure has been effected that the lordosis should be corrected and the strength of the structure should be restored. In most cases it can be accomplished by conservative methods of corrective exercises, or in some instances, by the radical method of prop bone graft.

In the author's experience, 60% of patients with clinical findings generally considered to be typical of disc protrusion, do not have a herniated nucleus pulposus when the spinal canal is explored. The symptoms are due to nerve root irritation or mechanical compression. A concealed disc or soft, bulging disc is not the cause, per se, of low back or radiating pain. Fusion of the spine of these cases with the vertebrae popped wide open have given universal relief from nerve root irritation.

The pathological picture is one of progressive degeneration and increase in lumbar lordosis with the advancement of age. In deference to Temple Fay and Chamberlain, forward flexion of the spine does not open up the posterior portion of the intervertebral space and cause a herniated disc to be sucked back into place. Flexion of the spine causes increased pressure within the intervertebral disc. At operation the ruptured disc has become tense and bulged when the patient's body was flexed to the lateral knee-chest position. It is true that the intervertebral disc is a buffer and may act as a cushion in absorbing shock but it does not act as a compressible elastic medium. The nucleus is a semifluid substance composed of 80% or more of water and follows Paschal's laws. Compression forces applied from any direction by flexing, extending or lateral flexion of the spine are transmitted equally throughout the incompressible nuclear material to be taken up by the annulus fibrosus fibers that are basket-weave in arrangement. Thus, the forces applied to the cartilage plate of the vertebra above and below the disc are equalized. The intervertebral disc is the toughest and most unyielding part of the vertebral structure. Complete curettement of the intervertebral disc seems illogical since it enhances the unpreventable degenerative changes that naturally occur with the advancement of age. Treatment should include removal of the extruded and loose nuclear material and fusion of the spine with prop bone grafts which correct lordosis and relieve nerve root compression. The results from this type of treatment are encouraging. The technique includes the modification of McBride's principle of apophyseal graft in conjunction with a "butterfly" type of prop graft between the spinous processes. Pictures and illustrations are shown. Poor results have been due to poor technique and failure to obtain satisfactory fusion. As technique has improved, the results have become proportionately better.

In discussing "Marie-Strumpell Arthritis and the Undiagnosed Low Back Patient" Baker (13) states that there is an apparent lack of knowledge of this disease by Medical Corps officers and the general medical profession at large. Many authors have classified Marie-Strumpell or rhizomelic spondylitis as a form of atrophic arthritis. This is probably a false conception because in the early stage of rhizomelic spondylitis there is an increased density of the subchondral bone in contrast to atrophy as present in atrophic arthritis. In addition, there is a favorable response of rhizomelic spondylitis to x-ray therapy in contrast to the poor response shown to atrophic arthritis.

Symptoms and Diagnosis: The most consistent early symptom is a vague morning backache of a lumbosacral type which, as stated by Herrick and Tyson, frequently disturbs the late hours of the patient's rest.

This pain is followed by relief with mild activity as the morning progresses, only to be followed by the return of pain in the evening after the day's activity. The onset most frequently occurs in the sacroiliac region, however, there are three common sites of onset: (1) the sacroiliacs, (2) the lumbodorsal junction and (3) the cervicodorsal area. The patients usually present themselves to the doctor in the third decade of life and are most frequently males, however, it is not uncommon for a female to have this disease. In addition to low back pain there may be associated sciatica and hip pain. If the early signs are in the lumbodorsal area, there may be a radicular pain which mimics intercostal neuralgia, pleurisy, or cardiac disease and because of the flank pain some of these patients are frequently seen in urological consultation. An occasional patient will have involvement of the peripheral joints, primarily the hips, knees and shoulders accompanied by synovial hypertrophy which makes it difficult to differentiate the disease from an atrophic arthritis. It may be that this group of patients actually present a mixed type of arthritis. Endocarditis or iritis are frequently present in this group. Temperature elevations are rare. During the active phases of the disease the sedimentation rate is the only laboratory procedure which may be abnormal.

X-ray Changes: Forestier in reviewing sixteen cases was able to prove by reinterpreting roentgenograms taken two, four or even eight years previously that sacroiliac changes were already existent and had been overlooked. As a rule early calcification and mottled trabeculation can be demonstrated in the subchondral bone adjacent to the sacroiliac joints with haziness and apparent widening of the joint spaces. Associated with these changes are pyknotic areas of increased density particularly in the lower poles of the sacroiliac joints. The findings are usually bilateral but more definite on one side than the other and in some cases may be confined to one side. Later the osteosclerosis present in the pyknotic areas advances along the subchondral area with destruction of the articular cartilage and trabeculation across the joint space. As the disease advances there is involvement of the joints of the articular facets of the spine and oblique films may show haziness and narrowing of these joints. Forestier differentiates between the osteophytes seen and non-ankylosing vertebral ossifications and ankylosing ossifications, which he calls syndesmophytes. This term means growths from the ligament in opposition to osteophytes, which means growths from the bone.

Treatment: The x-ray treatment as recommended by Hemphill and Reeves is reviewed and the efficacy of this measure in alleviating pain is stressed before the onset of other measures of treatment. As soon as the patient has experienced sufficient alleviation of pain following x-ray therapy attempted correction of deformities is started. A Gatch bed equipped with a sponge rubber mattress and a fracture board sewed in to conform to the Gatch bed is used for hyperextension in association with traction as required. A picture is shown of an apparatus which makes it possible to control the force used in obtaining hyperextension and to direct it to correcting the dorsal curve and developing the upper sacrospinalis muscle bundles. A picture of an operating table head rest which is adjustable in all directions is shown and which has attached shoulder supports to be utilized for the purpose of treating patients with deformities as a result of Marie-Strumpell's arthritis. In the treatment of these patients a brace to relieve pain and give further correction when the patient is ambulatory

is essential. The brace should incorporate an active force for maintenance of proper posture and at the same time be sufficiently comfortable to be tolerated. A picture of a suitable brace meeting these requirements is given.

Home therapy consists of continued use of the hyperextension bed, wearing of the described brace, continued corrective exercises, maintenance of an adequate diet and limitation of activity in keeping with the patient's disability. Rest periods of at least thirty minutes are recommended twice daily, and, when available, recreational and vocational guidance are invaluable as a part of the educational program.

The commonest factors entering into the etiology of back pain as they have been found in Bach's (14) experience are: 1. Myositis secondary to unusual exposure; to a sudden strain or trauma; to poor posture; to arthritis of the lower spine and sacroiliac joints; to backward slipping of the sacrum at the lumbosacral articulation. 2. Protrusions of the intervertebral discs. 3. Congenital malformations of the lower back in the neighborhood of the lumbosacral articulation. 4. New bone formation occurring in osteoarthritis. 5. Pathologic lesions in the pelvis and kidney that cause referred pain in the back.

The etiological factors of backache are discussed from the point of view of pain in the upper back, pain in the middle portion of the back and finally pain in the lower back.

Upper Back Pain: The commonest cause is an osteo-arthritis involving the cervical vertebrae, especially if the initial symptoms appear when the patient is over forty years of age. The exact mechanism of production of pain in these patients is not well understood. The most commonly accepted methods of treatment of osteoarthritis in the upper back are the same as encountered with this disease in any other part of the body. Special methods of treatment include the use of a Thomas collar or continued cervical traction by use of a Sayre sling.

Middle Back Pain: Pain as a rule is due to osteo-arthritis, rheumatoid arthritis, or myositis secondary to sudden exposure to cold or strain, while in rare instances it may be due to the presence of tumors. Consideration in diagnosis must always be given to the presence of pathology in the kidneys, bladder, prostate, adrenals, malignant new growths with metastasis in the lower spine; focal infections anywhere in the body, but particularly in the genito-urinary tract. Diagnosis is arrived at by consideration of history, physical examination and x-ray findings. The general practitioner is urged to make use of special consultations for these patients where required.

Low Back Pain: A review of the anatomy, pathology, physical findings, symptoms and the diagnosis of protrusions of pathological lesions of the intervertebral disc is given which in general conforms to the present consensus of opinion as expressed in medical literature. The conservative management of these patients is emphasized with the statement that most of them get well if they are put to bed, immobilized, given heat, massage and other therapy used in sciatica. After careful conservative

management of the patient and there is no improvement, the use of an orthopedic or neurosurgical or other allied specialist is recommended.

Shortening of a Leg: Leg shortening causing tilting of the pelvis may occasionally be the cause of pain in the lower back. This condition, unfortunately, is usually overlooked. A difference of even 1/4th inch should be considered as a possible cause of trouble if the patient is complaining of pain in the lower back, since tilting of the pelvis may produce strain in the sacroiliac joints and eventually lead to sciatic pain.

Pain in the Coccyx or Coccygodynia: Is usually caused by trauma which causes a dull ache that is aggravated by sitting on hard surfaces or rising from the sitting position. Rectal examination reveals tenderness over the center of the coccyx with forward tilting at a sharp angle of the lower part of the coccyx. Treatment of these cases, as a rule, is unsatisfactory, but should include hot baths, sitz baths and various analgesics and massage of the pelvic muscles with the finger in the rectum and as a last resort, removal of the lower end of the coccyx at the site of the apparent fracture. Surgical treatment of these patients is often times unsatisfactory.

Congenital Anomalies: The most common abnormalities of the back are spina bifida, sacralization of the transverse process of the fifth lumbar vertebra, forward or backward dislocation of the sacrum on the fifth lumbar vertebra and congenital abnormalities in the articular facets of the fifth lumbar vertebra. The presence of these anomalies is the cause of pain in only 50% of patients. The attending general practitioner should refer these patients to an orthopedic surgeon for advice and treatment.

Lumbosacral Disease: The lumbosacral joint is the weakest joint in the entire spine and because of the intimate association of the ligaments of this joint which also covers the sacroiliac joints and the nerves running down over the joints, it is usually quite difficult to make a clear-cut differential diagnosis. The most reliable sign is direct pressure of pain over the lumbosacral angle. The differential diagnosis is not extremely important because the treatment is the same in either case.

The differential diagnosis between lumbago, myositis, fibrositis and neuritis as factors in pain in the back cannot always be differentiated in any given case. The treatment is the same and, according to the severity of the case, one should employ rest of various degrees, salicylates in large doses, heat and massage, if tolerated. If satisfactory results are not obtained the patient should be given a course of x-ray therapy. If relief is still not obtained, absolute rest in bed for a period of at least six weeks, with or without a plaster cast on the back or a back support in the form of a brace or rigid corset is indicated.

Sciatica is a somewhat vague term used to describe a symptom complex distinguished by the fact that the patient suffers from pain in the back associated with a reflex pain that shows a marked tendency to run down the leg, along the distribution of the sciatic nerve. Sciatica is almost

always due to a pathological process located in either the sacroiliac or the lumbar joints or in their associated ligaments. The pathological processes which are most commonly found are trauma, infections, metabolic changes and malignancy. In typical cases of sciatica, the following positive physical findings are present: 1. A tilting of the upper part of the body toward one side or the other with a limitation of ability for forward flexion and lateral flexion. 2. Tenderness over the sacroiliac area of the affected side and in the sacrotuberous ligaments as in the lumbar joint, located about one inch from the midline in the angle between the ilium and the sacrum. 3. Limitation of straight leg raising. 4. Positive Gaenslen's test. 5. Positive Ober test. 6. Roentgenological changes with the patient in the standing, recumbent or lateral position.

After an accurate differential diagnosis has been made in these patients, treatment should include rest in bed for a period of from three to six weeks in a comfortable position, large doses of vitamin B, salicylates, gentle massage of the hips daily or at least three times a week, deep injection of novocaine, and finally, as a last resort, it may be considered wise for a consulting orthopedic surgeon to perform an Ober operation.

This article is a write-up of a clinical conference dictated by Dr. Americo Nunziata (15) on the subject of backache with and without sciatic radiation. A generalized discussion is presented of the mechanism of pain and common etiological factors of backache with and without sciatica, including arthritis, fibrositis, hypertrophic ligamentum flavum, sciatic neuritis, spinal cord tumors, spondylolisthesis, rupture of an intervertebral disc, secondary to degeneration of the disc, and postural backache. The pathological interpretation of diagnostic signs in association with the examination of a patient with backache and radicular pain is ably presented. Elevated spinal protein is considered helpful in the diagnosis of spinal cord tumors. Because of the high incidence of false negative myelographic studies of herniated intervertebral discs, a myelographic study of the spine is reserved for those patients suspected of having spinal cord tumors.

"Backache, Examination and Treatment" by Geckeler (16) is another article dealing with the history, physical examination and treatment of backache. Under history the author includes significant questions to be asked the patient with interpretation of the patient's answers. Physical examination includes an interpretation of the pathological signs observed in the patient. A plan of treatment of common back conditions, such as strain, sprain, congenital defects and anomalies, acute arthritis, chronic arthritis, degenerative changes, fascitis and backache with referred pain and also backache as a referred symptom is given. Conservative treatment outlined in the article is in general agreement with other opinions in the literature at the present time.

In contradistinction to pain caused by herniated disc material compressing a nerve root, West (17) believes that arthrogenic sciatica is produced by irritation of the funicular segment of one or more nerve roots where these lie in close proximity to the arthritic apophyseal joints, with associated vascular changes of congestion and swelling. The usual

primary cause of this apophyseal arthritis is degeneration of the corresponding intervertebral disc. As the disc further degenerates, the vertebral bodies approximate one another, throwing the apophyseal articulations into mal-alignment so that progressive arthritic changes develop in them.

Diagnosis: A clear-cut case of arthrogenic sciatica occurs in a patient of forty years or older who has lumbosacral arthritis as evidenced by chronic low back pain with limitation of movement. Excessive exercise aggravates the pain.

Treatment: No patient should be operated on who responds to conservative treatment. If there is any doubt about the origin of the sciatica, the patient is referred to a neurosurgeon for opinion. Eleven of this series of 52 patients have undergone laminectomy and exploration of the nerve roots. In six of these cases these procedures were followed by fusion at the same operation, and all patients were relieved of their sciatica. In only one case was herniation of disc material found. The other five patients had the fusion performed at a second operation. In two of these cases the discs were normal, two showed obvious degeneration and one other had a herniated nucleus pulposus.

At operation fusion from the second lumbar body to the sacrum is carried out. Two curved tibial grafts have been used in most of these patients, shaped so as to fit the lumbosacral curve as accurately as possible, and these have been reinforced by spongy bone and fine shavings. In those cases fused with iliac grafts only the percentage of failure of fusion has been higher.

Results: Listed below are the results in 37 cases in which more than eight months have elapsed since operation:

Table I.

<u>Results</u>	<u>Type of Graft</u>			<u>Combined Laminectomy and Fusion</u>	<u>Fusion after Previous Laminectomy</u>
	<u>Tibial Graft</u>	<u>Iliac Graft</u>	<u>Combined Tibial and Iliac Grafts</u>		
Good (26)	21	4	1	4	3
Fair (7)	5	1	1	2	—
Bad (4)	1	3	—	—	—
Total (37)	27	8	2	6	3

Twenty-six of the cases have resulted in complete and lasting relief from symptoms. Of the seven fair results only one man has any sciatica, in which case a limited fusion between the fifth lumbar vertebra and the sacrum was performed by iliac bone. Among the four failures, one woman died of paralytic ileus four days after operation. In the other three fusion was done with iliac graft. In two cases the bone has been absorbed and fusion has not occurred. One patient has since had a further operation, and practically no bone was found, and the remaining patient is waiting for re-operation.

According to Kaplan (18) the early diagnosis of a neoplasm of the cauda equina is almost entirely a laboratory procedure. If a patient with a "sciatic syndrome" is refractory to treatment and the etiology is obscure, then one must make full use of such laboratory procedures as the study of the spinal fluid and myelogram, to determine whether or not there is need for surgical therapy.

The author reports a case of neurofibroma of the cauda equina causing recurrent attacks of sciatica over a twenty year period of time. The history was characterized by attacks of pain lasting about 48 hours followed by relief of pain for approximately four to six weeks. Nine years prior to removal, the attacks became more severe and occurred every three days, during which time the patient was unable to walk, bend or bear any weight on the right leg. At no time were there any sensory or sphincter disturbances. There was a period of about one year when the patient was free of pain. Increase in symptoms one and one-half years prior to removal of this neurofibroma caused hospital admission. At this time the patient showed a halting gait, limitation in spine motion, spasticity of the lumbar muscles and absent knee and ankle jerks, with negative x-ray films of the spine. Spinal fluid was clear and colorless and there was no subarachnoid block, but the total protein was 200 mg. per cent. After several days of hospitalization symptomatic relief of pain was obtained and the patient was discharged from the hospital without proper follow-up of the elevated spinal protein. In September 1947, the patient was seriously incapacitated as a result of his recurring attacks of pain and he was readmitted to the hospital. At this time there was a loss of lumbar curve with marked spasm of the overlying muscle and the patient was unable to walk and hardly able to stand. The patellar and Achilles reflexes were absent. Jugular compression test reproduced the pain with radiation down the right leg. Sensory examination to all modalities was normal. There was no sphincter disturbance. On October 6, 1947, a laminectomy was performed from lumbar three to lumbar five vertebrae inclusive which revealed an encapsulated, olive-shaped tumor intradurally attached to the fourth lumbar root on the right side. The tumor and nerve root were resected and microscopic study showed a typical neurofibroma. The postoperative course was uneventful except for a moderate amount of abdominal distention. The patient was completely free of pain. Had this patient been properly worked up, a diagnosis most likely would have been made at an earlier date.

Backache in women according to Barns (19) may be due to abnormalities of the female genital organs, such as retroversion, prolapse of the uterus, inflammation of the uterus, or its appendages, pelvic cellular tissue or pelvic peritoneum; and neoplasms of the uterus or its appendages. It is the acquired type of retroversion that may cause backache. It is less frequently due to the mobile acquired retroversion as seen in the postpartum patient than to the fixed type. Backache may be associated with cervicitis and endometritis. Neoplasms of the genital tract may be associated with backache. Backache in the lumbosacral area in these female conditions is caused by an increase in tension in the posterior segment of the pelvic floor. It must be strongly emphasized that such lesions may exist without producing an increase in tension in the posterior segment of the pelvic floor and in these cases is not the cause of the accompanying backache. The lack of appreciation of this fact

accounts for so many patients having their backache attributed to a pelvic lesion whereas it is in fact due to an undiagnosed orthopedic cause. In order to treat the women with this disabling symptom we must first determine which of the many causes is responsible for the symptom in her particular case. This requires full examination of the spine, including x-ray of the pelvis and very often the help of the orthopedic surgeon, urologist or physiotherapist.

Moore and Cook (20) believe that the unstable spine, with or without ruptured disc is an orthopedic problem that requires intensive study for its proper evaluation. Most cases can and should be treated conservatively but some require operation. Conservative treatment is not conservative if it means that an individual who could be relieved by surgery is condemned to a life of semi-invalidism. In these cases operation is the most conservative type of treatment. Excellent results from surgery are difficult. They require excellent surgical judgment, an excellent operation, as well as excellent follow-up care. A movie was shown in association with this paper and demonstrates the prop graft operation devised by the author for surgical fusion of the unstable spine. Mental, physical and vocational rehabilitation is a part of the surgeon's total responsibility.

The authors believe an exaggerated lordosis is primarily responsible for the development of symptoms of back pain with or without sciatica. The back weakness predisposes to a rupture of the intervertebral disc with herniation of the nucleus pulposus. Operation to remove the disc does not cure the back weakness and, therefore, does not relieve the patient of pain in all cases. Reference is made to a recent survey of an insurance company which shows that 60% of patients operated on for rupture of the intervertebral disc had postoperative pain and disability. This finding coincides with the author's study which shows that 60% of the patients with typical symptoms do not have ruptured discs. The symptoms in these cases are due to narrowing of the intervertebral space which results in compression of the nerve root at the intervertebral foramen. For relief the spine must be blocked open or propped with a bone graft that holds it in position and permanently protects the root from any further pressure.

In an article on "The Painful Coccyx" Thiele (21) discusses the history, etiology, physical findings, diagnosis and treatment. He reports the results in 142 cases. Pain may be localized in the coccyx itself as a result of fracture or other direct injury, but it is usually not in the bony parts. Instead it is usually located in the sacrococcygeal joint or in the muscles which are inserted into the lateral borders of the lower sacrum and coccyx, namely, gluteus maximus, levator ani and coccygeus muscles. Coccygodynia is not due to rheumatism or neuralgia.

History: The chief complaint is one of pain or aching generally localized to the region of the coccyx or to the muscles and other soft tissues to one or both sides of the coccyx within a distance of about two inches. The exciting causes will include a prolonged sitting, falls on the buttocks, bumps, childbirth or ignorance of any cause. The severity of pain is in proportion to the length of time that sitting is continued without interruption. The most severe pain is experienced as the

patient arises from the sitting position. Symptoms of rectal or anorectal disease are often present. Frequently there is associated pain in the upper portion of the gluteal region and/or down the posterior aspect of the thigh along the course of the sciatic nerve. If acute trauma has been the existing factor, muscle spasm occurs at once and the onset of pain is sudden; if the trauma is prolonged as in long continued riding or sitting, the onset of pain is gradual. It is also gradual in those cases in which spasm and pain are secondary to focal infection in the anus, urethra, prostate, seminal vesicles or cervix uteri.

Etiology: In this series of cases etiological factors were determined to include anal infection in 89; direct trauma in 28; prolonged trauma due to long automobile rides or train rides 10; undetermined causes 10; prostatic infection 2; epididymitis 1; endocervicitis 1; and spinal cord tumor 1.

Physical Findings: Observation will reveal that patients sit down slowly and carefully, oftentimes close to the edge of the chair, with frequent shifting of weight from one buttock to the other. It is painful for the patient to arise from a sitting position. A large majority of these patients habitually sit in poor posture with the back convex and the lower sacrum and coccyx in contact with the chair, instead of sitting up straight with normal lumbosacral concavity. This is a causative factor in itself.

The normal coccyx has a rotation arc of 30 degrees with the sacrum, and may be moved laterally for a distance of about one centimeter from the midline. A pressure of 10 to 15 pounds against the tip of the coccyx with the thumb causes no pain or tenderness in the normal individual.

In performing a rectal examination, the gloved finger should be inserted the full finger-length and pressure made against the posterior rectal wall, the thumb being placed on the coccyx externally. Palpation of the coccyx between the thumb and forefinger is performed first and exquisite tenderness should cause one to suspect fracture. The examining finger should then be moved laterally, anteriorly and finally medially back under the symphysis pubis. As the examining finger is passed through this arc the gluteus maximus, levator and coccygeus muscles are palpated. When coccygodynia is present, spastic fascicles of the involved muscles will be felt, unless all of the muscle is in spasticity and then a broad, tight, flat band will be palpated. Anoscopic examination should be performed to reveal the presence of any anal infection. In the male the state of the prostate and seminal vesicles should be determined, and in the female the cervix should be visualized.

Diagnosis: The diagnosis of coccygodynia involves the following factors: Pain in the region of the coccyx, either alone or associated with sacral backache, pain in the superior gluteal region and down the course of the sciatic nerve. The pain is definitely and characteristically made worse by continued sitting, and is characteristically worst of all during the act of arising from the sitting position. Tenderness

on pressure against the tip of the coccyx may or may not be present, and is more often absent than present. Increased pain during the act of arising is due to added contraction of the levatores ani and of the inner fibers of the gluteus maximus with resultant increased traction on the coccyx producing stress on the sacrococcygeal joint. If coccygodynia has been accompanied by pain in the superior gluteal region or along the course of the sciatic nerve, spasm and tenderness of the piriformis muscle on the affected side will be found. Spasm of the piriformis muscles does not cause coccygodynia. Coccygodynia must be differentiated from the severe and sometimes lancinating pain accompanying acute anal ulcer. The differential diagnostic point is that with an anal ulcer, the sitting position tends to relieve rather than to exacerbate the pain.

Treatment: The treatment of coccygodynia consists of massage of the spastic muscles attached to the sides of the coccyx, and of medical treatment of and/or surgical removal of focal infection. One cannot too strongly condemn removal of the coccyx if the intention of the surgeon is to cure coccygodynia.

Salem (22) reviews the detailed anatomy of the intervertebral foramen including its contents in an article on "Low Back Pain Due to Narrowing of the Intervertebral Foramen." Special attention is paid to the anatomical consideration of the posterior primary foramen. Three case reports are in this article including one case of low back pain due to nerve root irritation caused by exostotic narrowing of the intervertebral foramen with subsequent relief by removal of compressing exostoses and resection of the involved intervertebral joint. Another case of narrowing of the intervertebral foramen, secondary to rotation scoliosis, is recounted with subsequent relief after removal of the associated intervertebral joint. A third case of a decreased intervertebral foramen which was manipulated is included in this article, the narrowed foramen being due in this case to extreme subluxation of the intervertebral joint.

It is essential that detailed x-ray study be made in these cases of low back pain in order to determine exactly the presence of a decreased intervertebral foramen. It is advisable to consider the intervertebral foramina as a source of low back pain and at operation to expose the foramina of the involved area in order to remove any impingement of the contained structures.

Cleveland, Bosworth and Thompson (23) have called our attention again to the fact that surgical fusion of the spine as regards mortality and complications has proved to be of minor importance, while failure of accomplishment of successful arthrodesis of a selected series of vertebrae in the lumbosacral region has proven to be of major importance.

In this series of cases, 647 operative procedures were carried out on 594 patients with an average postoperative follow-up period of 34 months. Pseudarthroses developed in 119 instances or 20% of the operative cases. One thousand three hundred and twenty-nine spinal intervals were bridged and pseudarthrosis occurred at 161 intervals among these patients, or an instance of failure of 12.1%. The incidence of pseudoarthrosis

increased with the addition of added numbers of vertebral segments. There was 3.4% of failure of fusion when only the lumbosacral joint was involved; 17.4% when the fusion extended from L-4 to S-1; and 33.3% of pseudoarthrosis occurred as additional segments were added. As the area of fusion is lengthened there is an increase in the incidence of pseudoarthrosis, but a marked decrease in the number of patients with solid fusion who are unrelieved of their symptoms. It is essential in determining the incidence of pseudoarthrosis to make roentgenograms of front and side bending of the lumbar spine. This will give view of a biplane dimension. Using this as a diagnostic criteria, 21% of the patients were shown to have pseudoarthrosis while only 11.8% were diagnosed as having failure of fusion by clinical judgment and flat roentgenograms.

Of the typical posterior herniations of the intervertebral disc, pseudarthrosis developed in 11.4%; this low percentage is attributable to the universal use of the clothespin graft, plus quantities of additional bone. Pseudarthrosis developed in 22.5% of those patients operated for lumbosacral strain; 16.1% of patients operated for tuberculosis; 23.2% of patients operated for spondylolisthesis; 29.7% of patients operated for arthritis of the spine; and 25% of failure in all others who were brought to surgery for spinal fusion for such conditions as foreign body, fracture of the lamina, hemivertebra, or scoliosis.

In reviewing this series of pseudarthrosis there appears to be a definite factor as the cause of pseudarthrosis in all but ten cases. In thirteen instances it was attributable to inadequate amount of bone. In five instances the pseudarthrosis was due to the use of solid, heavy tibial bone without support of iliac bone or other fine strip grafts. Infection, draining sinuses, hematoma, etc. occurred in ten instances. In five instances solid spine fusion had been fractured and at operation it was revealed the spinous process was separated from the underlying laminae at the upper end of the clothespin graft in two cases, and in three instances the fusion had been broken directly across. Crossing of previous laminal defects seemed to be the basis of pseudarthrosis in ten instances.

The new type of operative procedure was used for repair of the more difficult cases of pseudarthrosis. This repair consists essentially in denuding the laminae and the lateral margins of the articular processes, with extension of the dissection to the bases of the transverse processes on one side only. The medial portion of the transverse process is likewise denuded. A thin, wide flap is removed from the outer cortex of the ilium and implanted vertically on the transverse processes. Iliac strips are then placed over the denuded posterior elements of the involved vertebrae themselves; the angle between the implanted massive iliac graft and the mid-line being filled in with additional bone.

Brav, Molter and Newcomb (24) report a detailed and exhaustive survey of the measurements of 500 roentgenograms with special reference to the narrow disc and lower lumbar displacement. In the total

series a narrow fifth lumbar disc was noted in 26.4%; posterior displacement of the fifth lumbar was present in 10.2; anterior displacement of the fifth lumbar was present in 5% and there was displacement of the fourth lumbar vertebra in 3%. There was little difference in the 181 cases in which these changes were noted as to the presence of back and leg pain. As to physical signs the alteration in leg reflexes, limitation of straight leg raising and body tilt on forward bending in patients with altered x-ray findings of the fourth and fifth lumbar vertebrae were not significantly different from a control group of 319 cases without these changes. Except for the incidence of arthritis there was practically no difference in the clinical diagnosis of patients with altered changes of the fourth and fifth lumbar vertebrae and their interspaces than a control group of 319 cases without these changes. A study of the groups of patients with back pain alone, with associated leg pain and with neither of these complaints reveals no significant difference in the incidence of lower lumbar displacement in the symptom-free group. Posterior displacement of the fifth lumbar vertebra is apparently a definite entity and is not due entirely to difference in anteroposterior diameters of the fifth lumbar vertebra and the sacrum, although in about 20% this is apparently the reason for the appearance on the roentgenogram. It is possible that in cases of posterior displacement, there is secondary atrophy of the anterior edge of the sacrum which decreased the anteroposterior diameter of the first sacral segment. Anterior displacement of the fifth lumbar vertebra is usually associated with a defect in the interarticular portion of the vertebra and in at least 40% of the cases there is anterior lipping of the sacrum which increases the anteroposterior diameter of the first sacral segment. In cases of herniated nucleus pulposus or posterior disc protrusion, the incidence of narrowed fifth lumbar disc or lower lumbar displacement is not significantly greater than in the remainder of the series. Narrow disc on the roentgenogram cannot be considered clinical evidence of posterior disc protrusion. Narrowed fifth lumbar disc and displacement of the lower lumbar vertebrae are clinically significant only in that these conditions place strain on the already mechanically vulnerable lumbosacral joint. The weight of evidence seems to indicate that in most instances narrow fifth lumbar disc and lower lumbar displacement are in themselves not the cause of low back and sciatic pain. As is true in the case of transitional vertebrae and other lumbosacral anomalies, the presence or absence of back or leg pain depends almost entirely upon the integrity of the surrounding muscular and ligamentous structures. So long as these structures are intact, the patient may be symptom-free. When they are no longer able to compensate for the abnormal mechanical strain, pain may occur because of tension on muscle and ligamentous attachments, degenerative arthritic changes in the articular facets or actual pressure on the spinal nerves at some point in the region of the deranged lumbosacral articulation.

Little (25) reports a case of Calve's disease of the spine in a four year old boy with the past history, present status and x-ray examination. The chief complaint on admission was deviation of the head to one side and with an inclination to hunch his shoulders in a

peculiar manner when looking upwards. X-rays showed an unusual deformity in the upper thoracic region and further pictures showed this to be probably due to Calvé's disease of the spine with a marked collapse of the fifth dorsal vertebra associated with widening of the intervertebral disc space. There was a normal blood chemistry.

Mes (26) describes the surgical technique of lumbosacro-iliac arthrodesis. The operation is performed through an incision lying parallel to the last four lumbar spines and one inch lateral to them, sweeping distally across the posterosuperior iliac spine out laterally to end over the gluteal muscles. The essential component of the operation is to swing the incompletely osteotomized posterior iliac crest, including the posterior iliac spine over toward the midline to lie in apposition to the lower lumbar spines after surgical resection of the paraspinal muscles. The graft is held in apposition to the lumbar spines and laminae by use of chromic catgut or kangaroo tendon and the graft should be reinforced according to the Hibbs' technique. After osteotomizing the graft and before swinging it medially to place it into the prepared bed, the superior dorsal portion of the sacroiliac joint is resected in order to ensure a smooth floor for the bone graft. This operation is stated to be easy to perform and should have a better chance of bony union because of the retention of a part of the blood supply of the graft itself.

According to Turner (27) the traumatic type of low back pain is produced by too much tension or pull on the ligaments and muscles about the lumbar and lumbosacral articulations, resulting in tears in and about the origin and insertion of these muscles and ligaments. Treatment recommended is intracaudal (through the sacral foramen) injections slowly of 3 - 5 cc's triesthesia by using a special caudal needle customarily employed in caudal anesthesia in obstetrics. Following the injection the patient is carried through a normal range of lumbosacral motion. Novocaine and oil is used to prolong the action of the anesthetic agent rather than novocaine and saline. Injections are given from five to seven days apart and do not exceed three in number. The particular patients the author selects for treatment of this type are those associated with strain of the low back with sciatic nerve radiation or with radiation down the leg or into the hip joint. Treatment has been employed over a period of seven years and no complications observed. Conclusion is drawn that triesthesia relieves pain during period of healing of torn ligaments. No statistical analysis is given and opinion is based on author's clinical experience in the management of these patients.

Roche (28) reports an unusual case of bilateral fractures involving the isthmuses on both sides of the neural arch of the third lumbar vertebra secondary to a jeep accident. Photographs of the fracture are shown as well as photographs showing union of these fractures. This extremely rare condition was not noted in a series of 823 cases encountered in the Mayo Clinic from 1935 to 1939, inclusive.

The most lateral protrusion of a prolapsed intervertebral disc is termed subarticular prolapse by Hirsch (29). The table listed below shows the results of 23 cases in which complete or partial facetectomy

was performed. Only four of these had total facetectomies.

Table 3

Number of Operations	Patients free from pain in both back and legs	Patients free from pain in back	Patients free from pain in legs	Patients enabled to work
23	11	13	11	16

Three of the four cases who had total facetectomies are completely cured and free from pain, which suggests that secondary changes do occur after partial facetectomy in the operated joints. Of the patients included in this series, twenty had definite neurological signs, seventeen had negative myelographs and at operation fifteen disc prolapses were excised, nerve root compression being due to osteophytes in two cases. Twelve of the herniated discs were of the subarticular type. The table listed above clearly shows the poor results from this procedure. On the other hand, failure to look for a subarticular prolapse before spinal fusion may result in the burial of a prolapsed disc and this may be considered one of the causes of long-standing pain and discomfort. In conclusion the author considers that a more radical treatment, facetectomy, with subsequent fusion, is probably the treatment of choice.

The results of the examination of 100 lumbar specimens, 500 intervertebral discs and 1000 intervertebral joints are given in this excellent article by Friberg (30). The lumbar spines were removed together with the sacrum; the sacrum was fixed in a vise and as soon as possible after death the specimens were flexed and extended without forcing and were roentgenographed in various positions of flexion and extension. After a short period of formalin fixation the discs were cut horizontally and macrophotographed. The intervertebral joints were removed separately and decalcified, and sections were cut from all spaces in order to study the relation between disc and joint changes. The investigations have not yet been completed.

As the age increased the amount of fluid in the nucleus decreases, fibrosis increases and the borderline between the disc and the annulus becomes less distinct. This can be considered to be a natural aging process, but degeneration unquestionably occurs where fissure formation is found in the annulus.

In the upper lumbar disc degeneration showed in part a concentric arrangement; fissure formation being observed all around the disc. In the lower two lumbar discs the degeneration is situated mainly in the posterior portion and had a special form. Usually a sagittal path was seen going from the nucleus dorsally to the posterior longitudinal ligament, running out on both sides in the form of a "T" and often extending to a point slightly lateral to the intervertebral foramen. Other authors have pointed out that disc degeneration in the dorsal spine occurs in the anterior portion of the disc due to the increased pressure over the anterior rather than the posterior portion of the annulus.

In this survey disc degeneration was found in the backs of 32 cases and disc prolapse in 11 discs. Thus, it may be concluded that disc degeneration was more common and in cases where prolapse was observed, extensive degenerative changes were also present. In all cases where a disc showed roentgenological instability (posterior displacement) without other roentgenological indication of disc degeneration, reduction in the height of the disc, osteophytes and sclerosis of the vertebral bodies, fairly widespread fissure formation was nevertheless present in the annulus, especially posteriorly. Instability may thus be said to be an early clinical sign, but it implies the presence of advanced changes in the disc.

Exploratory laminectomy should be performed with caution because of the frequency of incapacitating backache postoperatively. Where instability of the lumbar spine can be demonstrated without evidence of disc prolapse, but only due to disc degeneration, increased incidences of lumbosacral fusion is recommended. Fusion of these lumbar vertebrae where instability exists would prevent several years of constant or recurring backache of these patients. This is a natural process which nature performs to arrest pain but sequence of events is too slow.

Parnell and Moore (31) present the results of 43 cases of low back pain treated by low spinal fusion, including the lumbosacral joint. Excellent results were obtained in sixteen cases, satisfactory in twenty and poor in seven. With few exceptions all patients operated on had demonstrable x-ray lesions. The operative technique was primarily a Hibbs fusion in association with screw fixation of the lumbosacral articular facets. In all cases the incision was a curved median longitudinal one which afforded surgical access to the posterior spine and posterior iliac crest for purposes of obtaining bone for grafting. As soon as the patients were able to stand comfortably postoperatively, a plaster cast was applied from the nipple line to the symphysis pubis in front and from the inferior angles of the scapula to the lower portion of the sacrum posteriorly. They were discharged from the hospital at this time and allowed to return to their homes and resume normal work as soon as possible. All cases of poor results were in veteran patients. Details of the management of the postoperative course of these patients is not included in this article and there is no analysis of the causes of poor results. The follow-up time, or method of follow-up of these patients is not included.

A series of 68 successive patients who underwent operations for ruptured intervertebral discs has been analyzed by Bradford (32) in an effort to determine the relative value of the accepted diagnostic signs. Sixty-one of the 68 patients explored for herniation of the intervertebral disc were found to have this condition or a percentage of 89.7% correct diagnosis. Sixty-one per cent were found on the right and 39% on the left. Forty-six proved herniations were at the lumbosacral space and only thirteen proved herniations occurred at the fourth lumbar space with only two herniations occurring at the L-3 disc level. Appraisal of the signs observed was divided into general signs and root signs.

General Signs: Coughing and sneezing were recorded as increasing root pain in 86% of the negative explorations and only 79% of the positive ones. The incidence of injury is higher in the negative than in the proved cases. Jugular compression increased radiating pain in 51% of positive cases and 29% of negative cases. Reproduction of pain by paravertebral pressure favored the proven lesion in the ratio of 59:43, and sciatic nerve stretching favored the positive group as 90:71. Sciatic scoliosis and reduced lumbar lordosis gave ratios, positive to negative exploration of 51:29 and 80:57.

Root Signs: Sensory changes were helpful in 61% of lumbosacral herniations and were misleading in only 2%. In fourth lumbar herniations apparent sensory changes helped in the diagnosis in 23% of cases and led to error in 15%. Ninety-five per cent of lumbosacral herniations showed a diminution or absence of ankle jerk. Absence of ankle jerk occurred in one fourth of lumbar herniations. Absence of the knee jerk was not observed, although diminution of knee jerk was observed in one patient with herniation of the fourth lumbar disc. In one of two patients having third lumbar herniation, the knee jerk was diminished and the ankle jerk was absent. Detailed motor testing emphasized in a prior publication by Bradford is of great importance in the diagnosis of disc lesion, especially those of the fourth lumbar space. In this series it occurred in 54% of fourth lumbar herniations, but it also occurred in 57% of negative explorations. Both of the patients in this series with third lumbar herniations showed dorsiflexor weakness. The author points out that gluteus medius weakness, with a waddling gait is not uncommon in involvement of both the fourth and fifth lumbar nerves.

An excellent article by Spurling and Grantham (33) dealing with all aspects of the problem of ruptured discs appeared in 1948. The authors state that a thorough knowledge of the anatomic relations in the lower lumbar portion of the spine and of the physiology of the intervertebral disc is essential for a clear understanding of the clinical features of this disorder. The pathological changes which occur in a ruptured lumbar intervertebral disc are irreversible; no surgical effort can hope to restore its anatomic integrity. A detailed discussion with appropriate illustrations are included in this article.

The authors believe the term "ruptured intervertebral disc, with or without herniation of the nucleus pulposus" more nearly describes the anatomic and pathologic features of the disorder than any other term. The term "hidden disc" seems to be an unfortunate one and in their experience usually represents a misnomer for a negative exploration. Multiple ruptured discs are rare. Low back pain unaccompanied by sciatic radiation is seldom, if ever, an indication for operation for a lumbar intervertebral disc. Unilateral, rarely bilateral, sciatica which is refractory to conservative treatment is the only significant indication for lumbar disc surgery. Patients in their initial episode of pain should have prolonged conservative treatment. A large proportion of them will get well without surgery.

Most patients with ruptured intervertebral discs whose symptoms are severe enough to justify operation present unequivocal neurological

signs. Not only are these signs invaluable and accurate in diagnosis, but they can be relied upon in over half of the cases for localization of the lesion. No matter how classical the history of a ruptured intervertebral disc may be, the patient should never be operated upon in a remission. This is one of the most common causes for negative explorations.

Disc operations may be among the most difficult surgery to perform properly. The operation should accomplish removal of all nucleus pulposus, loose pieces of annulus fibrosus and cartilaginous plates. A myelogram is not required for a diagnosis; it should be made on clinical findings alone. A myelogram is extremely valuable in localizing the lesion where neurologic signs are not clear-cut. Primary spinal fusion together with simple removal of a ruptured intervertebral disc is not a desirable procedure. These patients who continue to have incapacitating backache after simple disc surgery may require a secondary spinal fusion. A disc operation properly performed does not in any way interfere with subsequent fusion operation.

The follow-up results of 301 verified ruptured intervertebral discs treated surgically are presented. This survey was conducted by questionnaires and responses. Eighty and four-tenths (80.4) per cent stated they were able to do the same work at which they were occupied prior to operation. Fourteen and nine-tenths (14.9) per cent stated they were able to do their usual work part of the time but were handicapped by recurrent symptoms at other times. Four and seven tenths (4.7) per cent had to change their occupations because of persistent symptoms. Eighty and eight-tenths (80.8) per cent considered their operation to have been successful. Nine and six-tenths (9.6) per cent considered their operation partially successful and 9.6% considered it unsuccessful. Forty-seven and two-tenths (47.2) per cent stated they have no leg pain whatsoever, while 46.2% continue to have an occasional mild pain in the leg but not severe enough to be incapacitating. Six and six-tenths (6.6) per cent stated that they have aggravating leg pain constantly, in fact, just as bad as before they were operated upon. Thirty-eight and nine-tenths (38.9) claimed complete and lasting relief of symptoms of low back pain and fifty-four and two-tenths (54.2) per cent stated that they have occasional recurrence of low back disability. Only 6.9% claim to be completely incapacitated for their normal activity by persistent low back disability.

Crisp (34) presents an interesting discussion of treatment of lumbar disc lesion by immobilization in a plaster jacket. Lumbar intervertebral disc lesions are the usual cause of sciatica and a very frequent cause of acute and chronic backache. The patient with the tightly lordosed lumbar spine represents a partial rupture of the annulus with a slight bulge in the posterior wall, but with no actual protrusion. A kyphosed lumbar spine indicates a complete rupture of the annulus with an actual protrusion of the nucleus, but with the posterior longitudinal ligament remaining intact.

Muscle spasm of the paraspinal muscles is an attempt on the part of nature to immobilize the lumbar spine. It is, therefore, rational to assist nature by immobilizing the lumbar spine in a plaster jacket. This method of treatment provides more complete rest and more completely immobilizes the damaged disc than does treatment by rest in bed alone. The plaster should be applied with the patient standing in a position of greatest comfort. It

extends in front from the xiphoid process to the pubis, behind from the lower angles of the scapulae to the coccyx, and is cut away at the groin so that the patient can sit down. The plaster is changed at 30-day intervals, but is continued from six to eight weeks and thereafter the patient is supplied with a lumbar brace which is worn for a further period of three to six months. In cases of rupture of the intervertebral disc with sciatica, immobilization should continue in plaster from ten to twelve weeks. The aim of the treatment is to produce a fibrous ankylosis around the injured disc. In every case of a major disc lesion it is advisable for the patient to subsequently follow a sedentary occupation.

Between 400 and 500 cases of ruptured intervertebral disc have now been treated by immobilization in a plaster jacket and in approximately 90% of the cases, complete and permanent relief has been obtained. In the remainder, although the majority have experienced considerable relief, in a small number of cases operative intervention has been necessary. Surgery is reserved for those patients who cannot be made comfortable in a plaster jacket after two attempts.

In an article on "Low Backache, Sciatic Pain and Herniated Nucleus Pulposus" Rowbotham and Whalley (35) review the records of 200 operative cases of patients suffering from herniated nucleus pulposus in whom laminectomy was performed. All of the patients operated had been completely incapacitated as the result of low backache and sciatica for all kinds of work for at least four months. Patients with sciatica due to causes other than herniated nucleus pulposus were excluded from this series.

Signs and Symptoms: The percentage of patients suffering from the classical symptoms of herniated nucleus pulposus are included in this article. Thirty-eight per cent gave a history of injury and 64% gave no history of injury. One-third of the cases began with gradual onset of sciatic pain, while 26.5% had a gradual onset of backache as the presenting symptom. Twenty per cent had sudden onset of backache as the initial symptom, while 13.5% had experienced sudden onset of sciatic pain. Eighteen per cent of the patients had intervals of complete freedom from pain, while in 82% the symptoms had been continuous but of varying severity. Physical signs included 68.5% with severe limp, 75.5% with decreased lumbar lordosis, 64% with scoliosis, 41.5% had local tenderness over the sciatic nerve, 86% had limitation of straight leg raising, muscular atrophy was present in 40.5% and objective sensory changes were present in 29%. Restriction of spinal movement was most marked on attempted forward flexion with only 27% having restriction of spinal extension.

Accessory Methods of Diagnosis: Only one case of partial block of cerebrospinal fluid was demonstrated out of 67 lumbar punctures and Queckenstedt's tests. Spinal protein was elevated in approximately 50% of cases. Air myelography proved of little value and only seven cases had lipiodol myelograms done for the purpose of excluding tumors of cauda equina.

Operative Methods and Findings: Bilateral laminectomy was performed in 37% of the cases and hemilaminectomy in 63%. In the beginning of this series bilateral laminectomy was the usual procedure but as time progressed, hemilaminectomy was found to give adequate exposure in most instances. The choice of exposure must be decided at time of operation and depends upon anatomical and technical conditions. Too heavy retraction of a muscle group will damage

its nerve supply and lead to muscle weakness and postoperative complaints of pain and weakness in the back. The principle of the operation is not that of laminectomy but of adequate exposure of a given nerve root from the theca to the intervertebral foramen.

Types of Herniation of the Nucleus Pulposus: 1. Local protuberances due to loose fragments is the most typical type of herniated nucleus pulposus. 2. Local protuberances not due to loose fragments is characterized by an obvious conical mound at time of exposure. 3. The degenerated disc in which the protuberance is less conical, the base is broader and the swelling less localized. In these cases rupture of the annulus fibrosus has been extensive. 4. The fibrotic nodule is characterized at surgery by fibrotic nodules lying beneath the affected nerve root to which it is bound tightly by strong adhesions, requiring sharp dissection to free the nerve root. 5. Spontaneous rupture of a herniation is characterized at operation by dense gray adhesions around the nerve roots which are bound tightly to them by fibrous tissue and require sharp dissection for removal. 6. The intermittent protrusion of a herniated nucleus pulposus is a sessile type of protrusion and appears only on certain degrees of spinal flexion.

Long-Term Results: The patients included in this series were followed from three months to three years after operation. The survey showed that 96% of the patients were occupied in some form of employment and that only 4% were doing no kind of work whatsoever. The patients who returned to work did so, on the average, four months after operation. The results were poorer in Armed Service personnel than in civilians.

Residual Symptoms: Listed below in table form are the residual symptoms of the patients in this series:

Site of residual pain (if any)	Laminec- tomy (disc found)	Hemi- laminec- tomy (disc found)	Laminec- tomy (no disc found)	Hemi- laminec- tomy (no disc found)	Total
Back	11	6	1	2	(13.3%) 20
Back and leg	9	17	4	4	(22.7%) 34
Leg	3	7	0	0	(6.7%) 10
No pain in back or leg	23	59	2	2	(57.3%) 86

A detailed discussion of the results shown in the above table is included in the article.

Patients with no Herniated Nucleus Pulposus: A herniated nucleus pulposus was not found on 22 occasions out of the series of 200 laminectomies. In the present long-term review of 150 laminectomies there were fifteen negative explorations. Included in these fifteen negative explorations was one case of tuberculoma and nine patients with extradural root adhesions and five in

which no pathology at all was found. The case of tuberculoma was completely relieved of excruciating sciatic pain and five of the nine patients with extradural root adhesions had a satisfactory result. Four out of the five cases in which no pathology was found had a satisfactory result.

Potter (36) discusses the problem of "Protruded Disc Sciatica in the Services and its Management" under the following headings: 1. Assessment of the Pain: In order to accurately appraise the patient's pain, early transfer of these cases to a special center is recommended. Here the same medical officers will have the advantage of getting to know the patients during the period of conservative treatment, that, in all probability, will operate on patients if surgery be indicated. 2. Conservative Treatment: Bed rest for one month in all cases is utilized. In the absence of a definite history of pain being worse at night, patients suffering only mild amount of pain will object to this form of treatment. Aspirin and codeine and morphine, in rare instances are utilized for relief of pain. Diarrheas should be controlled promptly and irritating purges avoided because these enhance the discomfort of the patient. Scoliosis and hip flexion deformities are corrected as soon as the acute pain phase is passed by utilization of exercises, but manipulation later under anesthesia may be necessary. Cases with severe deformities are usually candidates for operation. After a month in bed, a week of graduated exercises follow, and the milder cases who are relieved of pain are returned to duty. Those who are unrelieved are out to bed for an additional month's rest. If essentially no improvement is shown after two month's rest and the case is not suitable for surgery, the patient should be separated from the Armed Forces. If the pain and physical signs become progressively worse with bed rest, neoplasm should be suspected. 3. Operation: No serviceman should be operated on for protrusion of the intervertebral disc unless it is absolutely necessary, because of the proportion of cases that return to duty is not satisfactory. 4. Indication for Operation: a. Indisputably severe or disabling pain prolonged for, or recurring over a period of at least two months, during which time strict bed rest has been observed. b. Severe neurological signs, such as marked involvement of the cauda equina, or great weakness in one or both limbs, notably such as to cause foot-drop. c. Severe tension signs: These include severe limitation of straight leg raising combined with marked limitation of spinal movement, in association with marked scoliosis or hip flexion deformity.

A statistical analysis of the history, symptoms, findings, laboratory examinations, operations and results of a series of dislocated discs in the lumbar region is reviewed by Lyerly and Grizzard (37). The most frequent site for a dislocated disc has been the fourth or fifth lumbar interspace in 96 to 98 per cent of cases, according to various writers. The discs involved in this series have been in the third, fourth and fifth lumbar interspaces with the majority at the latter two.

Table 1. Dislocated Lumbar Discs

Discs		122
Patients		121
Duplications		1
Male	83	68%
Female	39	32%

The incidence of dislocated discs of the lumbar spine is reflected in the following table in this series:

Table 2. Age Groups

<u>Years</u>	<u>Number</u>	<u>Percentage</u>
21-30	23	18.9
31-40	45	36.9
41-50	37	30.3
51-60	12	9.8
61-70	5	4.1

Table 3 below gives a statistical analysis of the symptoms of patients in this series:

Table 3. Symptoms

	<u>Number</u>	<u>Percentage</u>
Injury	97	80
Back Pain	114	93
Leg Pain	122	100
Sensory Change	80	65
Pain on:		
Coughing	93	76
Sneezing	84	69
Straining	69	55
No pain on:		
Coughing, Sneezing or Straining	19	15

Low back pain is the first symptom of a dislocated disc and precedes the sciatica or leg pain some days, weeks or months. Only 7% of the cases gave no history of back pain. Leg pain or sciatica was present in 100% of the cases. The history of pain on coughing, sneezing and straining is important since these acts raise the spinal fluid pressure and distend the dural sac. If there is a complete or partial blockage, the pain will be aggravated along the course of the nerve root.

Table 4: Findings

	<u>Number</u>	<u>Percentage</u>
Hypalgesia	98	80
Normal Sensation	24	20
Muscle Atrophy	22	19
Kernig	109	90
Lasegue	107	89
Naffziger	82	..
Positive	68	83
Negative	14	17
Not Stated	40	

Table 5. Spine

	<u>Number</u>	<u>Percentage</u>
Spinal Tenderness	96	79
No Tenderness	11	9
Not Stated	15	12
Lordosis	25	20
Scoliosis	42	34
Nerve Tenderness	50	41

In observation of the patient's spine the first thing noticed was scoliosis with listing to one side. Sometimes the listing was toward the affected side but sometimes to the other. The hip on the affected side was held higher so that there was convexity of the lumbar curve to the opposite side. In addition, there may be seen a flattening of the lumbar lordosis and in some cases a tendency to a kyphosis.

Abnormal tendon jerks were listed as diminished or absent. The knee jerks were abnormal in 16% of the cases, while the ankle jerks were abnormal in 60% of the cases. The reflexes were recorded as normal in 39%.

X-rays of this series were normal in 46% of the cases and no definite reliance could be placed as to the location of the disc or the presence of a disc in regard to the x-ray findings.

In this series of patients 22 had pantopaque injections or spinograms to aid in the diagnosis, but in the majority of cases with a typical history and neurological findings, the diagnosis can be made more readily and accurately without the aid of a pantopaque study. Atypical cases should have pantopaque studies made. In this series a positive myelogram for a disc was correct in 72% and incorrect in 14%. A false negative myelogram study was found in three cases or 14%. The pantopaque study should always be made when there is a possible tumor of the spinal cord or cauda equina.

Only twelve cases in this series had spinal fluid analysis with 58% of these showing increase in spinal protein and only 42% showing normal protein content.

Preoperative diagnosis of the disc involved was correct in 83% of cases and incorrect in 17%. Since the operative exposure included two or more discs at every operation, the slight error in the preoperative diagnosis made little difference. A single disc involvement was found in 72% of the cases. Two discs were involved in 23% and three disc lesions were found in 2.5% of the cases. The operative findings for disc involvement were negative in three cases or 2.5% of the series. In the negative cases the removal of ligamentum flavum and decompression of the nerve root may relieve the symptoms. The results have been good in the author's experience.

Only one patient was reoperated on for recurrence of a dislocated disc. A tumor of the cauda equina was found in two cases, including an intradural meningioma and a malignant hemangio-endothelioma which metastasized to other places in the spine and the brain, and the patient died in the hospital which was the only death in this series.

Table 13 below gives the results of the study in this series:

Table 13. Results (72 Cards, or
59 per cent, Returned)

	Number	Percentage
Slightly Improved	12	17
Greatly Improved	49	68
Cured	11	15
Working	63	88
Back Pains	54	75
Leg Pains	46	64

A large percentage of patients with disc lesions have back or leg pains at some time more than a year after operation although these symptoms may not preclude the patient from returning to work. Strenuous physical work is more apt to cause low back pain following disc removal.

There were 35 patients classified as compensation or insurance cases in this series and of these eleven replied to the statistical survey conducted. Table 15 below shows the results of insurance cases operated on:

Table 15. Insurance Cases (11 of 35 Cards
Returned)

	Number	Percentage
Slightly Improved	4	36
Greatly Improved	6	54
Cured	2	18
Working	9	81
Back Pain	10	90
Leg Pain	9	81

There was not a great deal of difference in the frequency of back and leg pains in the two groups after operation.

A detailed and exhaustive review of 100 consecutive cases operated on for intervertebral disc protrusion is reported by Falconer et al, (38) which includes a group of 77 cases where severe and intractable sciatica predominated, in conjunction with a group of 23 cases where severe and persistent low back pain predominated. The patients were selected from all grades of society from a much larger group of 300 to 350 patients referred for examination. The predominant neurosurgical signs were exacerbation and pain on coughing or sneezing, some degree of limitation of straight leg raising in nearly all cases of sciatica in association with a slight degree of weakness of the ankle movement. Rigidity of the lumbar spine was present in all cases of low back pain and in most cases of sciatica. Absence or diminution of the ankle jerk was often present with protrusion at the lumbosacral space, while sensory disturbances conforming to either the fifth lumbar or first sacral dermatome patterns were present in a large proportion of cases.

Each case of sciatica had disc prolapses at time of surgery either at one or both of the lower two lumbar intervertebral discs. All of these cases were improved on their preoperative status, although for various reasons nine cases required more than one operation. Forty-one percent of all cases were

completely relieved of leg and low back pain while the remaining cases had persistent symptoms, although appreciably lessened. All but two of the patients with low back pain had intervertebral disc lesions at operation. Benefit was obtained in all but two cases and only five cases of this group required further operation.

Selection of cases for operation was restricted to those who were unable to undertake light, continuous work and who had undergone a period of four to five weeks of complete rest without adequate relief after tuberculosis, neoplasm or other disease of the spine were excluded. A myelogram helps to localize the disc and foretell its nature, but is not absolutely diagnostic in all cases. In selection of cases for operation with low back pain without sciatica, more caution was observed. No patient with this complaint was operated on without positive myelographic evidence of disc protrusion. Adequate exposure of the affected disc is a mandatory surgical requirement. Removal of the ventral spine and lamina is performed in each instance where required and no increased disability has been noted in these patients. Recognition of pathological disc at operation is explained and divided into four types, namely, projections, extrusions, intermittent prolapses, and scarred discs. A description of these classifications is given. The definitions correspond to commonly accepted standards except that the term intermittent prolapse is used instead of concealed ruptured disc as described by Dandy. This type of disc can be made to protrude at operation by breaking the table so as to hyperextend the patient's hips and spine. This type of intervertebral disc protrusion occurred in 33 of the patients for a percentage of 27% of all discs removed at operation. Excessive mobility of the lumbar spine as indicated by forceful motion at time of operation helps in locating the diseased intervertebral space. Thorough curettage of the affected disc is the most important single precaution to be observed during an intervertebral disc operation. This should be accomplished even if removal is required to be carried out from both sides of the theca. Thickening of the ligamentum flavum and marked prominence of the extrathecal veins have been regarded as normal anatomical variations, but pronounced swelling of nerve root has been considered as a secondary factor of nerve-root compression and not as evidence of primary neuritis. In seven of the cases reported leptomeningeal adhesions causing matting of the roots of the cauda equina have been observed, but in each instance this condition was associated with a disc prolapse, followed by relief of symptoms in six patients. In none of the cases reported was a decompression of a spinal nerve root done at the level of the intervertebral foramen. Spinal fusions are not considered as improving the end result.

Fourteen patients in this series required a second or even a third operation because of persistent or recurrent symptoms and were classified as follows: a. Cases in which the disc lesion responsible for symptoms had not been recognized at the original operation--3 examples. b. Cases in which the responsible disc lesion had been dealt with inadequately at the original operation--8 examples. c. Cases in which subsequent symptoms were due to a second disc protrusion occurring at another level--2 examples. d. Cases in which spondylolisthesis developed producing symptoms--1 example.

At the second or third operation, in order to prevent opening the theca inadvertently, it is the author's practice to expose the lateral bony wall of the spinal canal and by dissecting the scarred theca from it to approach the posterior aspects of the vertebral bodies and so the intervertebral discs.

The recognition of other lesions which may simulate disc protrusions is essential to good disc surgery, and include tumors of the cauda equina, granulomatous disease of the intervertebral disc, tumors, diseases affecting the spine, and spondylolisthesis. Anomalies and acquired abnormalities of the spine demonstrable by x-ray examination are considered only as incidental findings or else secondary manifestations of the patient's complaint.

Intervertebral disc operations are liable to the same complications as other major surgical procedures, including wound infections, femoral vein thrombosis, pulmonary infections, etc. There are, however, some complications which are peculiar to this operative procedure and include extrathecal leakage of cerebrospinal fluid, spondylolisthesis, causalgia, acute postoperative aseptic leptomeningitis, injury to the aorta and inferior vena cava and paralysis of the cauda equina. The authors have not experienced all of these complications, but a discussion of these complications is presented.

Lindblom (39) describes a method of diagnostic puncture of intervertebral disc in sciatica. The indication for a diagnostic disc puncture is long-standing sciatica which has not responded to conservative treatment and which has a negative myelogram without definite localization of the disc protrusion. Under x-ray control, using a double needle, the inner one with a diameter of 0.5 mm. is introduced into the center of the disc and an opaque medium is injected. If the punctured disc is the cause of the symptoms of lumbago and sciatica, the pains caused by the injection will remind the patient of his usual complaints. Following injection appropriate x-rays are made which demonstrate the presence of a disc as it punctures through the posterior portion of the annulus fibrosis. Excellent pictures demonstrating the presence of a protrusion of an intervertebral disc are included in this article.

The diagnostic disc punctures have not been followed by any late complaints of the patient or other complications. At the insertion of the needle through the dural sac two patients experienced shooting pains from root puncture, but after a slight change of direction the needle bypassed the roots without causing pain. Too few cases have been done to fully appraise this method of diagnosis, but it seems to give great clinical promise.

Caldwell and Sheppard (40) examined and analyzed 75 cases who had undergone removal of a ruptured disc, three to seven years previously. Eighty-two and sixty-seven hundredths (82.67) per cent showed good results and 17.33% showed unsatisfactory results. Six cases were recurrent with good results, but for this reason were excluded. If these cases are included in the total of good results, it brings the percentage to 90.67 which compares favorably with the results obtained by Ghormley and associates; Smith, Deery and Hagman; and Barr in which the combined operation of spinal fusion and disc removal was performed. Reference is made to similar results obtained by Friberg five years after simple removal of the disc, in an examination of 47 patients. His series showed 83.8% of the patients to be relieved from sciatic pain and 70% to be relieved of back pain as well. If so many good results can be secured by laminectomy alone, the necessity of the combined operation of disc removal and spinal fusion may be doubted.

The incidence of recurrence from three to seven years after the first operation is 8%, but without exception, these patients were relieved of pain

in the back and lower limb for varying periods of time before and after the second operation. It is admitted that stabilization of the affected segments of the spine may reduce the percentage of recurrences, but it is remembered that the statistics of Bosworth and others on fusion of the spine show the failure of fusion occurs in 15 to 25% of the cases. Successful spinal fusion, according to Love does not in each instance prevent the recurrence of additional herniated discs. Statistical analysis of congenital anomalies does not indicate a higher percentage of unsatisfactory results in these patients. The hypertrophic changes with narrowing of the intervertebral disc or a combination of both conditions which occurs postoperatively following simple removal of the disc could not be shown to have any bearing on the good results obtained in these cases.

The incidence of good results can probably be increased when proper attention is paid postoperatively to the following factors: 1. Weight control; 2. A regulated increase in activity, compatible with the patient's age and general condition; 3. Special exercises to strengthen and increase the suppleness of the involved muscles. 4. An explanation to the patient of the cause of the residual pain; 5. Reassurance. This is perhaps the most important and may obviate the necessity for other measures. In conclusion, no criteria for spinal fusion following removal of a herniated nucleus pulposus are known.

Reviewing the history and physical findings of ruptured intervertebral discs Bakhsh (41) states that his object in writing this article is to create interest in this subject by the profession in order to increase the accuracy of diagnosis and institute proper treatment, which in his opinion is surgical excision of the intervertebral disc. The history most commonly found is low back pain for a variable period of time, followed by sciatic pain, accentuated by coughing, sneezing, forward bending or lateral flexion, with tingling or numbness in certain parts of the lower extremities. Physical examination reveals obliteration or alteration of the lumbar curve, scoliosis, elevation of the pelvis on the affected side, inclination of the body towards the sound side, positive straight leg raising test, positive jugular compression test, and the usual deep tendon reflex changes, in association with the usual altered sensory examination. Other conditions which are confused with ruptured intervertebral disc are granulomatous conditions of the spine, as syphilis, tuberculosis and other spinal affections, sacroiliac troubles and pelvic disease, especially in females.

Several microphotographs, diagrams, statistical tables and pictures are reproduced by Lindblom and Rexed (42) to show that macroscopically visible compression and deformities of the spinal nerve roots and ganglions by dorso-lateral disc protrusion are regularly associated with typical and often extensive nerve injury as clearly seen in microscopical sections of the nerves and ganglia. Diffuse degeneration mixed with regenerative processes of varying intensity were found especially in ventral root fibers. The spinal ganglion cells were often definitely deformed and atrophied by pressure and the spinal ganglion as a whole showed an increased amount of connective tissue and gross alteration in its internal structure. The severity of the nerve injury was on the whole proportional to the degree of the macroscopical compression. Occasionally osteo-arthritic enlargement of the intervertebral joints was found to be an accessory factor in causing nerve damage. The mechanism of compression and spatial relationship between nerves and the surrounding structures in the intervertebral canal are described fully. The relationship between

the nerve injury by the disc protrusion and certain arachnoidal proliferations around the spinal roots is briefly mentioned.

Holscher (43) reports a case of vascular damage to the greater vessels lying anterior to the fourth lumbar vertebra during surgical removal of the intervertebral disc between L-4 and L-5 by the use of the pituitary rongeur in the hands of a competent surgeon. The postoperative course of the patient is described in detail. Six months after disc surgery corrective vascular surgery was carried out transperitoneally through a lower right rectus incision. An aneurysmal sac measuring approximately three centimeters in diameter was found at the right common iliac vessels. The sac was obliterated by ligation of the artery and vein above and below it, after which the patient made a steady and progressive recovery.

Four other known but unpublished instances of similar vascular damage, each with grave results, are known to have occurred. The fatal outcome in the majority of these cases places this complication among the dire surgical emergencies. Upon the slightest suspicion of vascular damage large amounts of whole blood should be made available at the earliest possible moment. In any instance where the patient's circulatory condition shows marked change, there seems real indication to attempt immediate repair of the vascular injury. Because of the possibility of vascular injury it is advisable to routinely determine preoperatively the blood type and the Rh factor of the patient.

Shaw (44) discusses the possibility of ruptured intervertebral disc from positive acceleration in flight. The flexed spine may be injured by positive acceleration of magnitude which is readily withstood by the erect spine. For this reason it is advisable to maintain an erect spine during exposure to positive acceleration whether in curvilinear flight or in the ejection seat of an aircraft. A case of proven and a case of probable herniated nucleus pulposus resulting from a dive and "pull-out" are reported.

Dott (45) presents a synopsis of a paper entitled "Lesions of the Intervertebral Disc" under the Section of Orthopaedics of the 116th Annual Meeting of the British Medical Association. Protrusion of intervertebral disc substances occurred in approximately 300 new cases per million population per annum although insurance statistics tended to show that this was a conservative estimate. Trauma was an etiological factor in approximately 50% of the cases. Males were involved twice as often as females. In half of the cases radiological narrowing of the disc was found, and in a similar proportion there was a significant rise in the protein content of the cerebrospinal fluid. Bilateral syndromes might be produced by single disc protrusion or by a double lesion of the same disc or by single lesions of two discs. Skeletal peculiarities of congenital origin sometimes caused difficulty in localization of the ruptured disc, but otherwise were not of significance in relation to treatment.

At operation precise hemostasis was necessary with complete removal of all nuclear tissue effected by special gouges and nibblers copied respectively from those used by the dental surgeon and the otolaryngologist. In disc syndromes associated with spondylolisthesis the loose neural arch was removed, the prominent edge of the lower vertebra smoothed off, and after the disc had been removed, bone chips were put in its place and tibial grafts inserted

posteriorly. The author's experience in diagnosis was correct in 93% of cases and errors were generally due to the presence of multiple protrusions. Second operations were necessary in only 2% of the cases. Operative results showed no mortality, and 85% of the patients were fit for their former or equivalent jobs. Fusion operations were not necessary. Forcible manipulation was dangerous and epidural injection did not help.

In a discussion of the development of ruptured intervertebral disc, Raney and Raney (46) have the following to say. In selection of patients for operation the authors required: 1. Acutely disabling and intractable pain and physical signs of disc lesions not responding to physical treatment. 2. Recurring attacks of acute disabling pain and physical signs where it is economically unsound to continue conservative management. 3. Danger of irreversible neurologic changes (only occasionally encountered). Surgical treatment is designed to terminate the operation of pathogenic internal forces by removal of all abnormal material from the affected disc accompanied by intervertebral replacement of the disc with bone chips. The purpose of bone chips is not to produce a bony union but to maintain the joint space and provide a framework for cicatricial formation. In the majority of cases, the calcium had disappeared by the end of six or eight months without fusion. Since the fourth and fifth lumbar discs are so frequently affected, exploration of both of these is recommended at time of surgery with inspection of the third in case of doubt.

Part of the statistical analysis showed 168 of the cases to be private and 32 to be industrial cases. Of the private patients 85.1% returned to their original work, relieved; while 8.9% were relieved but changed to lighter occupations, making a total of 94% good results. Three and five-tenths (3.5) percent were relieved of their preoperative physical evidence of disease but continued to complain and were, therefore, classified as unimproved. Two and five-tenths (2.5) percent were unimproved, showing varying degrees of muscle spasm on activity and were suspected of having additional disc disease. Results of the industrial cases of which there were 32, were not so encouraging. Forty three and seven tenths (43.7) percent returned to their original work; 3.2% were unimproved; 34.4% were relieved of objective signs but did spotty work, remaining back conscious and compensation minded; 18.7% were relieved of objective signs but complained of pain when instructed to return to work. Part of the undesirable results in this group was attributed to poor handling of compensation by the insurance carrier.

If surgery is limited to positive findings by myelography, much of the disease will be missed. Leg pain will ordinarily be relieved but disabling backache returns from involvement of adjacent lesion or lesions in a sizable percentage of the cases. Spondylolisthesis, spina bifida, anomalies, facets, etc., were among the cases operated and the response to removal of the diseased disc or discs did not differ from the response in those cases with architecturally normal spines, however these defects may predispose to ruptured discs.

Approximately 80% of the patients suffering from diseases of the discs can be recognized by physical findings and clinical history, rendering spinal myelogram unnecessary and undesirable. Only those patients showing a variation from the typical picture of disc disease should be subjected to spinal myelography.

Wilson (47) reviews the present concept of diagnosis and treatment of protruded lumbar intervertebral discs with primary emphasis being placed on the necessity for a myelogram as a diagnostic procedure to be performed in each case of suspected intervertebral disc. Myelographic examination will show the correct level in 90% of positive protruded discs which are clinically apparent. Pantopaque is the material of choice and the types of roentgenological defects are classified as follows: 1. Lateral pressure defects. 2. Nerve root defects. 3. Hour glass defects (due to bilateral protrusion). 4. Gap defects (due to midline protrusion). 5. Block defects (complete midline occlusion). 6. Veil defects (incomplete midline protrusion in which the oil column is thinned as it passes over the defect).

The causes of false negative myelographic studies are attributed to: 1. Epidural injection of wall. 2. Large epidural varicosities. 3. Hypertrophic spurs of vertebrae. 4. Needle defect due to tension on the dura.

Protrusions most likely to be missed are those of the fourth and fifth lumbar vertebrae where the dural sac is narrow and the protruded disc produces no pressure on the oil column or on the nerve sheath. A negative myelogram is of value in those patients with apparent clinical ruptured disc because the disc will most often be found in these cases at the lumbosacral level. No series of cases is presented for statistical analysis and opinion is based primarily on author's clinical experience.

Black (48) discusses eleven cases of the massive herniation found in the literature and reviews three illustrated case reports. Analysis of the case histories reveals valuable information in arriving at a diagnosis preoperatively. Briefly stated, the composite picture is chronic backache for a variable period of time followed by radiation of pain into one lower limb and succeeded by relatively sudden onset of symptoms of compression of the cauda equina. The differential diagnostic point between this condition and collapse of a vertebra following invasion by tumor or collapse of vertebra weakened by infection can be made by suitable x-rays or by the characteristic slow onset of paralysis in these lesions. In contrast, the paralysis is relatively rapid when due to herniated disc.

Satisfactory recovery in the cases studied was in direct proportion to the rapidity of surgical removal following the sudden onset of a symptom complex of the cauda equina. An instance is cited in which there was a prolonged period between compression of the cauda equina and operation, leading to practically no improvement from surgery.

Briggs (49) states that sacroiliac subluxation does not exist as an etiologic factor causing low back disability, but only as a diagnosis causing confusion. Confusion is attributed to referred pain over the sacroiliac joint and its ligaments accompanied by a changed relationship between the sacrum and the ilium due to muscle spasm. Pain and tenderness are attributable to an actual stretching of the sacroiliac ligaments while a muscle spasm is due to the presence of an intervertebral disc. Operative procedures should always be directed toward the discs and never to the apophyseal joints. These patients are cured with lumbosacral fusion. Myositis and myofascitis, in association with indurated nodules in muscle masses are occasionally the cause of low backache.

Disorders of the intervertebral discs cause most of the pathological conditions for which operations are performed today. A description of the various locations of discs is offered with suggestions to prevent failure in the discovery of a ruptured disc. Foraminotomy with exploration of the root is a necessary procedure where indicated. The reader is reminded a herniated disc may be protruding preoperatively and not at operation due to a return of the ruptured disc to its parent site and to the positioning of the patient on the operating table which causes the disc to be sucked flat. The sense of feel helps tell the surgeon when the disc is pathologically soft, but the author recommends exposure of the disc to permit palpation and direct observation. Despite the author's surgical search for herniated disc and nerve root compression, operations with negative pathological findings are not infrequent. Pantopaque or any other contrasting material will not solve the problem. It will always rest, particularly in the fifth lumbar foraminal situation, in the judgement and skill of the orthopedic surgeon.

Herz (50) reports three cases of sciatica caused by cyst formation in an old hematoma in association with fascial fat herniations. Surgical removal of the herniated fat, plus the cyst formations in old hematomata, produced relief of backache and generalized sciatica. The cysts were removed from the buttocks. Pictures of pathological sections and a diagram showing the site of cystic lesions causing symptoms are included in the article.

A group of 95 postoperative disc patients were studied by Grant et al (51) in the Neurological, Orthopedic and Roentgenological Departments of the University of Pennsylvania. Sixty percent of the patients were regarded as cured and were able to pursue a normal full day's work without any back or sciatic pain, while 87% of the patients were satisfied with the results of the operation. The factors of age, trauma or type of occupation appeared to have no relationship to the type of injury and the type of operation appeared to be unrelated to the results. Air myelograms were helpful but not as sufficiently diagnostic as oil myelography, preferably pantopaque, and the recommendation was made that it be used routinely. The greater the displacement of nucleus pulposus, the more satisfying will be the result. Lost or diminished Achilles reflexes do not often return and recovery from paralysis is extremely uncommon. No relationship between increased narrowing of the intervertebral space and clinical result can be shown. Fusion of the vertebral bodies or dense bridging occurred in six patients, all of whom are in the group of clinically well. It could reasonably be postulated that more will develop this change as time goes on, but further follow-up studies will be necessary to substantiate or disprove this point. It is unlikely that the presence of a significant quantity of residual opaque oil in the caudal sac has any influence upon the clinical result. The fundamental principle for good results is careful selection of patients with exclusion of those cases that fail to measure up to an exacting history and physical examination supported by a positive myelogram.

Friberg (52) reviews the anatomical relationship of the nerve root to the lumbar disc and presents pictures of anatomical specimens which illustrate this relationship. Special emphasis is placed on the relationship of the fifth nerve root which leaves the dural sac at the level of the fourth disc, but does not leave the spine until the level of the fifth disc is reached.

Instability of the lumbar spine is considered to be a fairly early clinical sign of disc degeneration and can be suitably detected in a large number of cases by x-ray examination. The roentgenological instability demonstrated was one of anteroposterior displacement of a vertebra toward the adjoining one. Instability of the spine is associated with an extensive rupture of the annulus fibrosis. This finding has been arrived at as a result of detailed postmortem examinations of 100 cases.

In performing the removal of a disc, a myelogram is considered an essential adjunct in order to determine accurately the level of disc interruption. At surgery the minimal amount of dissection is performed in order to shorten the period of convalescence and a laminectomy is not done unless absolutely necessary. Spinal fusions have not been performed following removal of a ruptured disc except in those cases where a resection of the intervertebral joint, or a facetectomy has been performed, to remove a lateral prolapse. Of 800 operative cases, 60% have shown excellent results and 24% have shown good results or a total of 84% results entirely satisfactory.

At operation the bulging part of the disc pressing on the nerve root is removed and loose parts from the disc cavity are also removed. Scratching or thermocauterization is never done. The removal of an entire disc is unnecessary since the weight-bearing structure of the fibrous ring is not the nucleus pulposus. In two and five year follow-ups of many patients operated on there has been little roentgenological evidence, if any, of disintegration of the intervertebral space.

Early surgical intervention in patients with sciatica is not warranted since a large percentage of these patients respond to conservative therapy.

Abercrombie (53) states that the minor signs of displacement of intervertebral discs are the plantar sign, the "forced expiration" sign, and a vertical lumbar spine. The plantar sign is due to an atrophy of the tissues of the sole of the foot, giving rise to an appearance of wasting, and an increase in the number and depth of the corrugations of the plantar skin. These changes have atrophic origin. The "forced expiration" sign is reproduction of a patient's disc pain produced when the patient closes his nostrils with his fingers and then made an expiratory effort. This is more reliable than the sudden violent strain caused by coughing and sneezing since these actions are thought to aggravate the pain of fibrositis or myalgic condition of the back or chest wall. The vertical lumbar spine sign is increased extension of the lumbosacral joint as determined by x-ray examination.

Craig and Kessel (54) wrote some interesting observations concerning arthrogenic sciatica and disc prolapse. They make reference to an article published by Mr. E. F. West, of Adelaide, in the 13th of December, 1947 issue of the Australia Medical Journal which stresses that limb pain may arise from lumbar joint derangement independent of disc prolapse. Lewis and Pochin have shown that in paralysis of a nerve due to pressure, touch sense fails early, motor power fails next, immediate pain later and delayed pain last. Alternating periods of numbness and cutaneous tingling are the earliest signs of root compression. Painful stimulation of a deep somatic structure such as an interspinous ligament by injection of hypertonic saline results in pain throughout the corresponding sclerotome with accompanying muscle spasm and is indistinguishable from that occurring spontaneously in an L-5 and S-1 disc lesion.

Herniation of the nucleus pulposus is primarily a joint lesion since it causes strain on surrounding ligamentous structures and may secondarily give rise to spinal or nerve root compression. This is further evidenced by the fact that a large proportion of patients in whom disc prolapse is subsequently found at operation never present any acceptable evidence of nerve pressure, such as muscle weakness, anesthesia or loss of deep reflexes. Removal of the disc will reduce mechanical disturbances of the surrounding tissue and thereby diminish the irritation which gives rise to segmental pain, but it will not invariably abolish the pain, because in some cases the joint remains grossly deranged, to act as a constant source of painful stimulation. Spinal fusion is, therefore, essential, however this is a severe and time consuming procedure.

To further support the argument presented, application of a short plaster cast without preliminary extension may very rapidly relieve pain, although anesthesia persists and may actually increase. In addition, the injection of 1% novocaine into the corresponding interspinous ligament in cases of prolapsed discs will produce relief of pain lasting from a few hours to three weeks.

In a discussion of the syndrome of protruded intervertebral disc, Oldberg (55) reviews the anatomical background, symptoms, laboratory tests and presents three illustrative case histories, gives treatment and prognosis of protruded intervertebral disc. The anatomical background and concept of symptoms is in accord with the general understanding of these subjects. The importance of x-ray examination is stressed with the statement that at least 75% of the cases will have negative x-ray examinations. Lumbar puncture is not routinely recommended but is declared mandatory in those cases in which there is possibility of any other lesion being the cause of the patient's pain. Myelography should be reserved for particular cases in which it seems especially indicated, with the reservation that, as radiologic techniques improve and the substances used for myelography are also improved, this procedure may become more universally used and even essential. In consideration of treatment, surgery is not recommended until conservative measures have been adequately tried and until recurring symptoms with resultant disability have proved beyond doubt that one must proceed surgically. In conservative management of these patients it is essential that weight lifting be avoided and that the patient sleep upon a stiffened mattress. Physiotherapy almost always does harm. This is certainly true of mechanical manipulation, either active or passive, and is even true of diathermy and similar treatments in a fair proportion of cases. When surgery is performed, adequate exposure is essential and the author removes as much bone as may be necessary to obtain adequate exposure which may be a half or a third of the lamina. All loose pieces of disc material are removed, including those within the cavity of the disc itself but no other operative technique is followed.

In reference to prognosis, the author believes that patients with a ruptured disc will always have a weak back. He does not consider it advisable to return the patient who has sustained an injury while doing heavy labor to this occupation.

In a discussion of the conservative treatment of lumbar disc lesions Crisp (56) states that the majority of lumbar disc lesions with or without sciatica generally recover completely if treated by adequate conservative

measures. Bed rest, in itself, is insufficient. Muscle spasm is an attempt on the part of nature to stabilize the lumbar spine. A plaster cast applied with the patient in the most comfortable position, extending from the manubrium to the symphysis in front, from the inferior angles of the scapulae to the coccyx posteriorly, and cut out to allow the patient to sit, will furnish added and almost complete immobilization of the spine, thereby relieving the patient of his pain and allowing him to return to his former occupation quickly without prolonged hospitalization. Immobilization allows reparative processes to occur, including adaptive shortening of the ligaments and muscles at the site of the lesion and restriction of forward motion. After removal of the cast the patient is given hyperextension exercises, but forward flexion is allowed to return naturally. Three patients with acute sciatica following rupture of an intervertebral disc were shown, wearing plaster jackets.

English and Spriggs (57) made a study of eighteen cases whose findings were compatible with diagnosis of herniation of the nucleus pulposus. Seven cases had relief of pain following lumbar sympathetic ganglia block. It was not possible to rule out the possibility of infiltration of the sciatic nerve root with some of the procaine at the time of injection. In order to obviate this possibility, tetraethylammonium chloride, which has a selective action on sympathetic and parasympathetic systems, was utilized in a series of eleven cases. Eight patients had complete relief of pain; two had some residual pain; and one patient had no relief of pain. The period of relief from pain was quite variable, lasting from thirty minutes to 28 days in two cases with still no return of pain at time of publication of the article.

Based upon this evidence it appears that sympathetic ganglia are either directly involved in the transmission of pain in certain cases of herniation of the nucleus pulposus or that blockage of sympathetic pathways in some way relieves the pressure around the nerve root near the site of the disc material. Two explanations are offered for the relief of pain in these cases: (a) Afferent pain carrying fibers course through the sympathetic ganglia, or (b) Sympathetic fibers are involved in the production of increased nerve root pressure near the site of the herniation of the disc by virtue of a vasospastic phenomenon and increased swelling.

Young (58) believes that disc degeneration is more often revealed by injury than it is caused by injury. When an intervertebral disc degenerates the fibrocartilage of the annulus breaks up and becomes soft, thus allowing an abnormal degree of movement to occur between the two vertebrae concerned. Such abnormal mobility has nearly always been present in the cases the author has referred for surgical treatment. This excessive mobility can sometimes be demonstrated radiographically and is the earliest effect of the disc disease. Reparative processes are difficult and nature attempts to compensate for the abnormal mobility by shortening the surrounding ligaments. If ligamentous shortening keeps pace with the degenerative process there will be no abnormal mobility and no symptoms. In contrast, if shortening lags behind the degeneration, the disc will be abnormally mobile and symptoms may occur. Later in the degenerative process osteophytes form at the margin of the vertebral bodies and produce the radiological appearance which we know as spondylitis. Ankylosis is the final result of the ligamentous shortening and is nature's method of healing a disc lesion. The symptoms of intervertebral disc disease with the rational explanation of them is discussed in detail.

Various means of conservative treatment are outlined. If all of these methods fail surgery is indicated.

A very excellent discussion of rupture of the intervertebral disc in the cervical region is presented by Brain, Knight and Bull (59). The anatomy, pathogenesis, symptomatology, diagnosis and treatment are covered in great detail. The indications for conservative and operative treatment are presented.

In an article on the intervertebral disc syndrome, Lewin (60) discusses a historical review of the disc syndrome from as far back as 1555 with the works of Vesalius in describing the consistency of the annulus fibrosus and that of the nucleus pulposus. A statistical review of the signs and symptoms of various authors is included. In localization of the intervertebral discs reference is made to Love and Walsh who showed that 96% of all ruptured discs occur in the lumbar region and 96% of these are protrusions of the fourth and fifth lumbar discs with almost equal frequency of occurrence at each of these sites. The author feels it only necessary to make a diagnosis of herniated disc because of this fact. The diagnosis of a ruptured intervertebral disc at the fourth and fifth interspace is made on low midline lumbar backache, plus pain down the back of one or both legs, which is intensified by coughing and sneezing and must be recurring and not continuous. There may or may not be diminution of the Achilles tendon reflex or sensory or motor loss in the distribution of the fourth and fifth lumbar and first sacral nerves. Accessory diagnostic tests should be avoided wherever possible. The most reliable sign helpful in the diagnosis of protrusion of the lumbar disc are Lasegue's sign, sciatic nerve tenderness or diminution or absence of the Achilles tendon reflex on the side of pain. Consideration of differential diagnosis is given to a tumor of the cauda equina; congenitally defective fifth lumbar vertebra with destruction of the articular processes; and spondylolisthesis, all of which are relatively uncommon. The last two can be differentiated by roentgenograms and spinal tumors will give sensory and motor disturbances, in addition. Love's operative technique for removal of herniated disc is given. The question of combined operation of spinal fusion and disc removal is left to the individual surgeon. Where combined procedures are performed a neurosurgical and orthopedic surgical team is recommended.

Kidner (61) discusses low back pain and sciatica from the standpoint of anatomy, diagnosis, causes and treatment. The causes include muscular strain, joint sprains, hypertrophic arthritis, systemic infection, fractures, congenital anomalies, anatomical abnormalities, local joint diseases, intrapelvic conditions, ruptured disc and acute low backache due to minor injuries. The author concludes that the vast majority of backaches are due to lesions exactly like those that occur in joints, bones, muscles and fascia throughout the rest of the body. Many cases of sciatica are due to these lesions because of the proximity of the lumbosacral nerve roots to the affected tissues. The vast majority of cases can be cured by conservative means with rest being emphasized as the most important requirement. Rest is obtained by recumbency in bed, specially designed braces, casts, and as a last resort, surgical fusion. Manipulation in selected cases is recommended in order to break up adhesions and correct faulty positions. Corrective exercise, massage and heat is used to restore normal posture and relieve pain. The author admits the entity of a ruptured disc and surgical removal is indicated in these patients. The diagnosis of a ruptured disc is considered difficult and its

removal does not always produce a cure. Conservatism in treatment of low backache with sciatica is recommended.

Under the title of "Herniation of Fascial Fat, A Cause of Low Back Pain" Hucherson and Gandy (62) report 32 patients who were operated on for painful palpable masses in the low back. The findings agree with those of Herz, Copeman and Ackerman. All of the patients in this series complained of backache of varying degree of intensity with sciatic or radicular radiation of pain reproduced and exacerbated by palpation of painful masses in the low back. These trigger points occur along the lateral border of the sacrospinalis muscle from the costal margin to the crest of the ilium. In the gluteal region, they are found about the posterosuperior iliac spine and along the crest of the ilium or about 5 cm. below it. These trigger zones are also found in line with the sacroiliac junction but are not commonly found elsewhere in the buttocks. The distribution of these areas corresponds to the normal distribution of fat beneath the posterior fascia. In differential diagnosis of this condition no sensory changes or reflex phenomena or muscular weakness has been noted. Injection of the painful nodule with 1% novocaine will afford temporary relief and should always be carried out as a diagnostic procedure. The infiltration of these areas may be curative.

Copeman and Ackerman classified these fat hernias into three anatomic types: the pedunculated, non-pedunculated and foraminal. The latter term has reference to the penetration of the last three lumbar cutaneous nerves through the deep fascia and through these fascial foramina, the fat globules may protrude. Microscopic examination of tissue of all the cases reported shows nothing except entirely normal adipose tissue. None showed evidence of edema or inflammatory reaction. Nerve tissue was observed in some of the sections but the finding is not constant.

Fair, good and excellent results are recorded in 30 of 32 cases with only two failures. The major proportion of these cases gave an excellent result. Follow up time is six months to two years and an excellent result was obtained in all but seven of the cases. Five of these seven patients believe they have experienced enough relief to warrant the operative procedure and the results were classified as good or fair. One failure was due to inadequate work-up and the other failure cannot be explained.

Gurdjian and Webster (63) report an analysis of 196 cases of herniation of the nucleus pulposus operated on between September 1940 to September 1946. The operative findings in these cases includes 146 ruptured and protruded discs, 28 cases without disc herniation, 9 cases in which 2 discs were found, 8 massive ruptured discs and 3 calcified discs. Neurological findings were either classified as mild or severe. In those patients with severe neurological findings the onset of these changes may be very rapid in association with massive rupture of the intervertebral disc. The operative findings in those patients without ruptured intervertebral disc include 12 cases of varicosities of the outgoing root, 7 cases of root compression by contiguous tissue, 1 herniation of cauda equina filament through the dural opening and 8 normal cases.

Preoperatively all patients had spinal fluid examinations and in the greatest majority the total protein was slightly elevated, the average being

50 mg.%. In only four patients was the total protein above 100 mg.%. The operative findings and myelographic findings corresponded in 21 cases out of 31 in which this procedure was performed. In the remaining 10 there were false-positive or negative findings. Every patient had roentgen studies of the spine made preoperatively and in 27 of the group significant coexisting spinal abnormalities were noted. In 20 patients there was a narrow disc but only in seven did this correspond to the affected interspace while in 13 the narrowing occurred at other than the affected interspace.

The operative procedures, as carried out in this study, included bilateral laminectomy in 23, hemilaminectomy and exposure of the fourth and fifth interspaces on the affected side in 121 and combined laminectomy at the fourth and fifth interspaces on the affected side with fusion of the lumbo-sacral spine in 52 patients. The fusion consisted of the use of tibial graft, cancellous bone and osteoperiosteal graft. The non-laminectomized side was mainly used for the graft. In a few patients the procedure advocated by Moore was used, the graft being applied with the patient in flexion to get the maximum separation of the vertebrae posteriorly. Most of those patients in which fusion was performed were ambulated in approximately two weeks.

Follow-up studies on 80 cases show only 12% poor results, with 43% excellent, 25% good and 20% fair results. Of the 25 patients fused, results include 8% poor, 24% fair, 32% good and 36% excellent.

Nine patients had secondary operations with satisfactory results with the exception of one patient in whom a cordotomy was performed as a last resort. Among the reoperated patients, material was removed from the same interspace in two instances and from another interspace in the remaining three, with one patient having a nerve root protruding through a small opening in the dural sac with a spurious meningocele. Compensation cases have not done as well as private ones. There have been little differences in the cases in which combined fusion and removal of the disc was performed in comparison to those cases in which simple removal of the disc was accomplished. Exploration of the fourth and fifth interspace routinely on the side of the pain, as suggested by Dandy, is a satisfactory and a recommended procedure.

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SECTION 12

CONDITIONS INVOLVING THE THORAX AND DORSAL SPINE

Prepared by Leroy O. Travis, Major, M. C., U. S. A.

Posture

The importance of dynamic posture in reducing fatigue, preventing accidents and increasing one's well-being is discussed by Howorth (1). The basic dynamic posture is characterized by a slight crouch, with ankles, knees, and hips flexed, the head and trunk inclined forward, the arms relaxed, and the trunk and arms slightly flexed. Illustrations show correct walking, climbing, sitting, reclining and lifting.

Anomalies

Torgerson (2) presents radiological evidence of the association of lumbosacral defects with anomalies of the coccyx, kidneys and lower intestinal tract in 2 cases; of hemispondylos, kyphoscoliosis, defects in an arch of a vertebra or hypoplasia of a vertebra with inversion of viscera in seven cases; and of anomalies of the spine with constitutional peculiarities of an endocrine nature in 2 cases. The observations seem to indicate a developmental relationship stemming from the primitive notochord. Similar observations have been made in amphibia and short-tailed mice.

The various anomalies observed in the study of 150 radiograms of normal individuals (adult Indians) and 12 skeletons are presented by Ginde and Kurulkar (3). Some type of anomaly was present in 66.3%; spina bifida occulta was observed in 20.6% of the cases; a total incidence of 6% of cases of cervical ribs was observed in the roentgenological studies.

Brodkin (4) presents a case (11 year old girl) of congenital chondrosteral depression, another term suggested for "funnel chest", relieved by chondrosteronoplasty. He believes it to be a congenital deformity due to a short central tendon of the diaphragm. The indications for operation are given as (1) disturbance of cardiac function (operation delayed in his case because signs and symptoms suggested rheumatic fever) and (2) unfavorable effect on the emotional state of the patient, particularly girls. A prophylactic operation, as described by Brown, for young infants is described, as well as the plastic procedure of elevating the sternum by traction using silver wires at the angle of Ludwig and the lower end of the gladiolus.

Tumors

Although early diagnosis of tumors of the rib cage is relatively simple, their removal is frequently delayed until they have undergone malignant degeneration. Poppe and Berg (5) present 2 cases of osteochon-

dromata operated upon before sarcomatous degeneration. Roentgen therapy is recommended for the occasional Ewing's sarcoma or multiple myeloma of the ribs, but for osteoplastic metastatic carcinoma surgical removal will often relieve local symptoms for many months. A radical resection, frequently including 3 ribs and parietal pleura (if tumor overlies the free pleural space) must be done. A practical technic is described for closure of the rib cage defect by overlapping the adjacent ribs.

Chest Closure

In order to meet the problem of a satisfactory closure of the chest wall after thoracic surgery, Naclerio (6) has proposed a clip-on subperiosteal band to go around the adjacent ribs. The stainless steel bands are made in 5 lengths which are quickly placed beneath the periosteum so as not to impinge on the intercostal nerves. The patient can move about safely, comfortably and freely immediately after operation.

Sternochondral Joints

The sternochondral joints from several hundred cadavers were examined by Gray and Gardner (7) revealing the presence of fibrocartilage in all of these joints, and an interarticular ligament in the second joint in less than half the cases. The fibrocartilage, not present at birth, obliterated the cavity of the joint either partially or entirely, or formed strands which usually passed obliquely across the cavity. It seems likely the fibrocartilage arises in response to the unusual mechanical stresses of the repetitive and multi-directional movements at these joints.

Scheuermann's Disease

Knutsson (8) has, by serial roentgenograms on cases of Scheuermann's disease, using the nucleus pulposus as a marker, demonstrated that horizontal growth takes place by means of an appositional growth from the anterior surface of the vertebral body. Vertical growth may be inhibited by the disease, resulting in a sagittal or frontal wedge shape in the localized type, or an intact but flattened rectangular shape in a more uniformly distributed process. In all cases the diseased vertebrae have augmented sagittal depth.

Scoliosis

The subject of scoliosis is reviewed by Ryan (9) in a lecture as part of a refresher course. He covers the history of scoliosis, its classification, embryology, anatomy, diagnosis and treatment. He traces the history of scoliosis from Hippocrates to the late 19th century. The principles of extension, derotation and lateral correction still form the basis of treatment. He gives two classifications and some contributing factors to be considered. He describes in detail the embryology of the vertebral column as it develops through mesodermal changes about the notochord, to help explain the anatomical variations which arise. The blood

supply to the vertebrae is also discussed as a source of the bony abnormalities. The gross anatomy and physiology of the sections of the spinal column are presented as they apply to the production of scoliosis.

Rarely can a diagnosis of scoliosis be suspected until the child assumes the erect position, and even so in 80% no cause will be found and an inherent muscle weakness or mild central nervous system lesion must be assumed.

He emphasized the differentiation between the primary and the secondary curve as a prerequisite of treatment. The primary thoracic curve may be symptom-free in the older patients, while the more mobile secondary lumbar curve produces distress due to continued muscle strain and the onset of arthritic changes in the spine. Although treatment is admittedly not ideal, satisfactory correction can be obtained in the clothed individual. The first stage in treatment is an attempt to mobilize the spine and to develop the muscle tone by exercises and manipulation. Where any known etiological factor is present and active it must be corrected primarily. The apparatuses which have been devised to assist in correcting the deformity are discussed, including the author's derotating chair. Later plaster jackets may be used, with exercises as described by many authors. To maintain correction, fusion of the spine is usually necessary. Fusion of more than seven vertebrae should not be undertaken at one stage. In children, he recommends fusion when the ossification in the vertebrae has progressed sufficiently to maintain the correction. This may be accomplished when X-ray films indicate complete attachment of the iliac crest throughout its length to the ilium.

In order to assist in the mechanical correction of scoliosis preliminary to fusion, Scudese (10) suggests a lateral flexion apparatus on which the patient is placed for casting. The cast may be windowed for operation. The apparatus consists of 2 adjustable turnbuckle troughs firmly hinged to a bar which fits into the pelvic rest of a fracture table. The patient is placed on the apparatus with the apex of his curve directly over its apex. Roentgenograms are used to check correction of the deformity. A plaster is applied from head to knee on the convex side of the body, from head to greater trochanter on the concave side and covering both arms to the elbow.

The medical complications of kyphoscoliosis are well presented by Bland and Goetz (11) with reference to a 45 year old woman who had severe scoliosis secondary to poliomyelitis at 6 months of age. She was being studied for cardio-respiratory symptoms in preparation for surgery for carcinoma of the breast. Previous cases who died of lung failure before heart failure and some following the giving of morphine are discussed. One case was relieved by walking on all fours "like a bear" and another was relieved by hyperextension in bed. In these cases the primary fault is in the thoracic cage which cannot inflate the lung adequately, resulting in a sort of "thoraco-cardiac failure" usually with dilatation of the right heart. Some have lived to the fifties or sixties but the average^{age} of death is 30 years. Digitalis in these cases has no virtue. They may develop psychoses due to lack of oxygen. Adequate oxygen and even artificial respiration will help keep these patients alive but some go into acute ir-

reversible failure despite all efforts. Surgery is debatable on spines with such long-standing deformity that cardio-respiratory symptoms are pronounced.

Osteomyelitis

Two cases of vertebral osteomyelitis secondary to lumbar paravertebral novocain block are presented by Brown and Hoffman (12). Apparently these are the first two such cases. Both were battle casualties. The blocks were administered for pain and coldness of the limb due to posterior tibial nerve severance in one, and to severance of the posterior tibial artery and vein in the other. The cases are described in detail and the differential diagnosis between pyogenic and tuberculous osteomyelitis of the spine presented. In both cases there was an acute, more or less febrile onset after the blocks with persistent back pain and paravertebral spasm. Bony destruction with evidence of new bone formation occurred early, with ultimate fusion between the 1st and 2nd and the 2nd and 3rd lumbar vertebrae in 5 and 10 months respectively. Symptomatic relief was obtained by the application of plaster fixation. Both cases received penicillin and eventually recovered.

Mayer (13) presented a case to the Royal Society of Medicine with apparently a double pathology: (a) old vertebral epiphysitis previously undiagnosed involving L2 in a 25 year old male, and (b) subcutaneous abscess of the back arising in the same area by hematogenous or lymphatic spread from a recent furuncle over the right scapula. Under local and systemic penicillin therapy with aspiration of the abscess, the acute pyrexia and superficial lesion cleared up, but X-ray findings were unchanged. The sclerosis and new-bone formation seen in X-rays 10 days after the onset of symptoms are not consistent with a diagnosis of staphylococcus osteomyelitis of a vertebra.

Paraplegia and Soft Tissue Ossification

Abramson (14) has analyzed the relationships between bone atrophy, urinary calculi and soft tissue ossifications in 56 cases of paraplegia. These ossifications never occur above the level of the lesion. In his cases the blood serum calcium, phosphorus and phosphatase were normal. Ambulatory patients were considered those who had walked for at least two years for an hour or more nearly every day. Most patients led a wheel-chair existence and had an aversion to ambulation. There was a striking difference in the incidence of calculi, osteoporosis and soft tissue ossification in the two groups. The earlier the ambulatory ones started walking, the lower was the incidence of these complications. Only eight cases fit the ambulation category. It was felt that the pressure on the bone in ambulation produced bone matrix, thus allowing the deposition of calcium in the bone, and not in the urine and soft tissues. The only logical therapeutic agent which applies pressure intermittently is ambulation. Active, passive exercises and massage had no influence on the bone atrophy.

The thoracolumbar syndrome is described by Jacobs (15) as a common cause of backache. The thoracolumbar spine, because of certain mechanical and anatomical factors, which are described in detail, is susceptible to frequent strain and irritation. Irritation of the 12th thoracic or first lumbar segments may produce symptoms simulating sacro-iliac and lumbosacral pain, or any of several urologic, gynecologic or surgical problems. The consistent objective findings in this syndrome include: 1. The pain may involve the 11th thoracic thru 1st lumbar segment unilaterally or bilaterally and is very variable in intensity and duration. 2. Hyperesthesia as well as tenderness on deep palpation over the trunk of the involved nerve may usually be elicited. 3. There is invariably limitation of spinal motion and some scoliosis. X-rays taken with the patient standing show the depressed twelfth rib, lumbar scoliosis, pelvic tilt, and internal rotation of the head of the femur on the side of the low crest of the ilium. The most effective method of therapy is perineural injection of procaine by the technique described, associated with the correction of obvious postural defects.

The intervertebral ligaments have been further studied experimentally as a source of segmental pain. Sinclair et al (16), using human volunteers, injected saline into and around the intervertebral ligaments with X-ray control to ascertain the exact location of the point of the needle. In the thoracic region injections as nearly as possible to the midline caused referred pain much less readily than injections to one side. In the lumbar region injection of as much as 0.6cc of hypertonic saline into the midline caused only local pain in the back and failed to cause referred pain. It was assumed that referred pain was caused by direct stimulation of the nerve trunks and not by stimulation of the interspinous ligaments as proposed by Lewis and Kellgren, whose views are presented and discussed at length.

Industrial backaches were studied in 90 consecutive cases by Loopesko (17). Adequate treatment by progressive fascial ligamentous loosening was given to 77. Patients were released after an average of 10.2 days with 5.2 treatments, and only one case required hospitalization. All went back to full duty. Two thirds had no lost time. Most cases complained of low back pain, but there were also cases of cervical, dorsal and upper lumbar area strains, some being brought in by ambulance because of their severity. The proper psychological handling and instruction of patients being so treated is most important if patients are to adhere to the treatment and receive its benefits. The rationale of the treatment is based upon the theory that peripheral nerve irritation may be produced by outside compression, as by contracted fascial ligamentous bands. The technique includes active exercise by the patient and passive stretching by the surgeon, under short relaxing anesthesia if necessary. Passive stretching includes straight leg raising in adduction past 90 degrees, and hyperextension in adduction and abduction, just a little beyond the point of definite resistance, with care to prevent nerve damage. He urges institution of the regime immediately after an industrial injury likely to produce backache by excessive strain causing tear of fascial fibers. In a plant cited, lost time due to such injuries had been reduced practically to zero.

Noble (18) studied 104 cases of painful back in a Veteran's Hospital in Canada. The average age was 33 years. The etiology of the backaches ranged from postural and traumatic strains, bone injuries, spondylolisthesis, tuberculosis and ankylosing spondylitis to intervertebral discs treated conservatively and operatively. He discusses specific exercises and immobilization, and summarizes the results of treatment. He concludes that when a protruded intervertebral disc can be diagnosed, operation may not necessarily restore the laborer to normal activity: 2 of 16 returned to full duty. He emphasizes that the patient with recurring traumatic strain may be in the early stages of a disc lesion. This study indicates the value of the lumbosacral brace, particularly in those cases who have had a laminectomy without fusion and who have residual back symptoms. A study of the nature of the trauma resulting in chronic back pain suggests that the best treatment may be prevention by postural training, particularly in the military and industrial establishments, to assist in overcoming the human constitutional weakness at the lumbosacral junction.

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SECTION 13

CONDITIONS INVOLVING THE HIP JOINT

Prepared by Alfred H. Bungart, Lt. Col., MC, U.S.A.

Coxa Plana

In discussing pseudocoxalgia, Korvin (1) feels that the pathological process in the femoral epiphysis is one of aseptic necrosis and not of some infectious process.

Waldenstrom's sign - (an increased distance between the medial pole of the head and the floor of the acetabulum) - was commonly noted very early, even before any fragmentation could be observed on x-ray. Associated with this sign it is observed that there is an alteration of the contour of the acetabular floor which appears to be abruptly hollowed out. Experimental work has led to the conclusion that both Waldenstrom's sign and the alteration of the acetabular floor are the result of pressure from a markedly swollen and edematous ligamentum teres.

In some instances, cyst-like areas of absorption may be observed in the neck and acetabulum. These are usually attributed to an extension of the osteochondritis. The author opposes this theory and feels it is part of the process of osteoporosis and is seen in other states such as osteoarthritis, rheumatoid arthritis and osteomalacia in which osteoporosis is a feature. The cyst-like areas heal spontaneously with the healing of the underlying pathology, i.e. when the epiphysis regains its normal texture.

The amount of deformity undergone by the femoral epiphysis before it regenerates is the main factor in determining the ultimate shape of the upper end of the femur. However, this is not the only factor. Deformity of the femoral neck may develop very early in the course of the disease, even before appreciable deformity of the head. Some cases present on x-ray, a tilting of the epiphysis due to a forward bending of the neck before any real deformity of the epiphysis itself can be detected. These constitute Legg's mushroom type with a favorable prognosis. The author attributes the bending of the neck to an osteoporosis.

Although it is generally considered that there is no pathological change in the articular cartilage, the author found an early pathological change in 5% of his 102 hips studied.

A brief review of the history of the osteochondral conditions of the hip is presented by Graham (2). It would appear that all of these conditions have the one thing in common, of disturbance in the blood supply to the head of the femur. The author describes the blood supply to the head of the femur as being from three sources: arteries in the ligamentum teres; vessels in the capsule, especially in posterior capsular artery; and vessels entering the head from the marrow. In the case of congenital dislocation of the

hip the blood supply from the ligamentum teres is absent and the most important source is through the capsular arteries. A brief review of the classical symptoms and physical and x-ray findings is given for congenital subluxation and dislocation of the hip, for Legg-Perthes' disease and for slipped capital epiphysis. In the review of treatment, the author favors long continued traction and recumbency in the treatment of Legg-Perthes' disease; open reduction in true congenital dislocation of the hip and the use of the Smith-Petersen nail after replacement or wedge osteotomy in the case of slipped capital epiphysis. Four cases are presented as illustrative of the points mentioned. The main theme of the paper is the author's plea for earlier and more adequate treatment of these childhood conditions in order to prevent the complications which invariably follow.

Draznin and Singer (3) report a case of a five-year-old-white female found to have Gaucher's disease. A splenectomy was done to prevent bleeding. The child made an uneventful recovery. She was followed closely and at the age of ten was found to have typical signs and x-ray findings of Perthes' disease. At the time of her marriage at the age of twenty-one, she was again examined. She had a good blood picture but some enlargement of the liver. On x-ray she had the typical deformities of Perthes' disease with bilateral flattening of the femoral heads, severe coxa vara and areas of radiolucency and sclerosis of the femoral heads, necks and proximal shafts. In addition she had the typical x-ray changes of Gaucher's disease in the lower end of the femora consisting of the Erlenmeyer flask appearance with widening of the medullary cavities, thinning of the cortices, and numerous areas of radiolucency in the shaft.

A review of the past and present theories as to the etiology of Legg-Calvé-Perthes' disease is presented. The authors feel that the condition now referred to as Perthes' disease may be a manifestation of one or more conditions, such as Gaucher's disease and although a given case may prove to be a pure hip joint process, every effort should be made to rule out any other condition. In other words, Legg-Calvé-Perthes' disease is very often not a definite clinical entity but rather a syndrome of many etiologies. Such factors as trauma, infection, endocrine dysfunction, vascular accidents, etc., must also be considered as etiologic agents. Much work remains to be done before the final pages are written on this obscure condition.

Based on the theory that the basic pathology of Legg-Perthes' disease is an aseptic necrosis on the basis of deficient circulation, Zadek and Berkett (4) have attempted to encourage and facilitate the revascularization by multiple drillings into the involved area. Ten cases are presented and reviewed. The drillings were carried out either by arthrotomy and retrograde drilling or from the side, much as one inserts a guide wire for nailing of a hip. Postoperatively the patients were kept from weight bearing by one or more of the usual means such as recumbency, traction, cast or caliper brace. The follow-up period ranged from two to twelve years. The conclusion of the author is that no alteration in the course or end result was obtained from the surgery. There was no shortening of the length of the regeneration process and no ill effects were noted. The results of the study lend credence to the theory proposed by Legg, that there are really two types of the disease, one in which the head becomes flattened and mushroomed centrally, and the other in which there is a tendency toward flattening associated with

more fragmentation and migration of the flattened head toward the greater trochanter. Legg felt that the eventual outcome depended for a great part on the type encountered regardless of weight bearing or recumbency.

Haythorn (5) reports a study made of the material obtained from the curettings from the head and neck of the femur of thirty-one cases of Legg-Perthes' disease. All cases showed essentially the same pathological picture, varying only in the degree and amount of change. Constant findings were aseptic necrosis, compression of the various bone elements, and incomplete healing process which was going on concurrently and to little purpose. The necrosis involved all the tissues present to varying extents and included destruction of marrow with bony trabeculae recognizable but without nucleated osteocytes or osteoblasts. Cartilage showed fragmentation, degeneration and imperfect ossification. Intermingled with the degenerating areas were islets of healing including simple fibrous replacement of marrow stroma which was infiltrated sparsely with lymphocytes and occasional leukocytes. Areas of osteogenesis and osteoclysis were jumbled together and the normal line of ossification of the epiphyseal cartilage was lost. The lesions are thought to be due to nutritional disturbances associated with vitamin and growth hormone deficiencies.

In a discussion of early coxa plana, Stahl (6) states that the exact age of onset is difficult to determine for there is always a period of vague symptoms prior to the time the patient seeks medical aid. Also it appears that there may be a period in which the process is active before the symptoms even in the mildest form appear. The earliest x-ray evidence is flattening of the anteriorposterior contour of the capital epiphysis and an increase in the distance between the contour of the head of the femur and the acetabulum (Waldenstrom's sign). Brailsford is of the opinion that the process has existed for two to three months prior to the time that these x-ray findings are noted. The most common age at which the condition is brought under medical attention was six years; the average patient had noted some symptoms of the condition for one year prior to the original examination. Of the cases studied there was an average of sixteen months existence of the condition before x-ray evidence of repair could be detected and the condition took an average of three years for total repair. It was the general feeling of the author that the process of repair was somewhat more rapid the younger the patient was at time of the onset.

Slipping of Capital Femoral Epiphysis

A number of papers on the subject of slipped capital femoral epiphysis appeared in the orthopaedic literature during 1948. Generally speaking there was an unanimity of opinion concerning the treatment of this condition. Badgley, Isaacson, Wolgamot and Miller (7) gave five postulates which have been their yardstick for the treatment of this condition. These are:

1. A displacement of not more than one third of the diameter of the femoral epiphysis has been accepted as a satisfactory position. These cases as well as those which show even less displacement are treated by internal fixation without any attempt at alteration of the position of the epiphysis.

2. Displacement of the upper femoral epiphysis beyond this extent, usually associated with deformity and disability, requires improvement of the position of the epiphysis in its relation to the neck.

3. Skeletal traction had been used for the reduction of the displacement. Should a satisfactory reduction result, its maintenance by internal fixation until the femoral epiphysis had closed has been the most successful method of treatment. The acute traumatic type or the chronic slow form suddenly complicated by trauma will usually be corrected by this method.

4. Unsuccessful skeletal traction necessitates open reduction of the displaced epiphysis. Not infrequently removal of a wedge of bone anteriorly has been required in order to attain the proper alignment. It is advisable to maintain the position thus gained by means of internal fixation.

5. The ultimate fate of the neglected and displaced upper femoral epiphysis is most certainly degenerative arthritis. Correction or prevention of the displacement has been the rule of therapy. The subtrochanteric or intertrochanteric osteotomy has been reserved for the patients with the mal-united, fused upper femoral epiphysis and a hip that has maintained fair or good motion but has external rotation deformity.

The main theme of the entire paper is the early recognition and internal fixation of the slipping before the later and damaging stages of the condition can be reached. It is considered far better to attack the condition in the later stages by an osteotomy of the neck in the region of the epiphysis than to resort to the trochanteric osteotomy, for in the latter case no correction of the original and basic pathology is attempted and the mechanics of the hip are still in the altered state.

Seventy-eight hips are reviewed in light of the methods advocated for treatment of the various stages of the condition. In the older cases requiring wedge osteotomy and internal fixation for correction, 56% obtained excellent results and 32% poor results. In open reduction without internal fixation, 36% obtained excellent results and 46% poor results. Open reduction without wedge and with internal fixation produced 50% excellent results and 25% poor results. Closed reduction with internal fixation showed 83% excellent results and 17% poor results. Internal fixation without attempted reduction had 69% excellent results and 25% poor results. Subtrochanteric osteotomy showed 50% excellent results and 25% poor results. The unaccounted cases in the statistics ranged from good to fair results.

The major complications noted in the operative procedures for the correction of this condition are traumatic arthritis and aseptic necrosis. Only 4% of the hips operated revealed x-ray evidence of aseptic necrosis; 24% revealed x-ray evidence of traumatic arthritis. This latter condition developed in two patients in which no therapy had been attempted and in two in which blind nailing was done. It would appear that the operative procedure is not the only factor in the production of this complication and that some intrinsic predisposition exists toward such a complication.

The generally conceded poor results in the treatment of slipped femoral epiphysis is re-emphasized by Martin (8) and the blood supply to the capital

epiphysis is presented for clarity. During the preceding seven years twenty-six patients have been treated and from these certain conclusions are drawn. It is felt that closed reduction should be condemned except in the unusual case of the acute displacement of less than two weeks duration. Even then only the most gentle manipulative reduction is permitted, consisting of gentle traction and internal rotation and if successfully reduced by this means the epiphysis should immediately be fixed by a Smith-Petersen nail. If the slipping has been more gradual or of more than two weeks duration, open reduction should be performed without any attempt at closed manipulation. The open reduction advocated by the author has as its watchword GENTLENESS. No attempt should be made to lever the head onto the neck, but instead a wedge osteotomy is performed with the base of the wedge superior and anterior and just distal to the epiphyseal plate. The neck of the femur is then carefully brought into alignment with the proximal epiphysis and a Smith-Petersen nail inserted over a guide wire to fix the fragment. It is emphasized that care must be exercised in opening the capsule in the superior aspect and that the periosteum must be carefully preserved about the neck of the femur and when the operation is concluded reattached to the bony structure. The procedure has been utilized on seven patients in whom the follow-up has been sufficiently long to draw final conclusion. Of this group six have been classified as excellent. The seventh patient has limitation of motion and a marked limp but it is felt that this failure was due to the fact that the nail was driven through the head at the time of the fixation and the patient used the leg sufficiently to produce damage to the acetabulum. It is not due to any failure in the principle advocated but purely to a technical error.

Sten Friberg (9) reports that seventy cases of slipped capital epiphysis which were nailed with the usual three flanged nail before more than one third slipping had occurred gave very good results. The rule upheld by many other authors is reiterated i.e. if there is more than one third of the epiphysis displaced, open reduction is indicated. The author has performed the wedge osteotomy, generally advocated, on thirteen cases with more than one third slipping. The wedge is classically removed at the epiphyseal line with the base superior and anterior and the head replaced and held by a three flanged nail. It is felt that the use of a guide wire facilitates the nailing by preventing the tendency for separation of the osteotomy line when the nail is driven. In the thirteen cases reviewed, twelve are sufficiently followed for appraisal. Ten of the twelve have excellent results; one case presented a total necrosis of the head which was noted prior to surgery, in one case there was a partial necrosis which disappeared.

Seventy-three cases of slipping of the capital femoral epiphysis are reviewed by Ponseti and Barta (10) in the light of treatment and the end results of such treatment. The cases were in different stages of displacement and were divided into five groups depending upon the amount of the displacement. The ages of the patients varied from eleven to seventeen years in boys with an average age of 14.1 years. In the girls the age varied from ten to fourteen years with an average age of 12.1 years. Interestingly enough, one boy with bilateral displacement and one girl with unilateral slipping were age twenty and twenty-five respectively and both cases were complicated by deficiency of the pituitary growth factor and closure of the epiphysis had not yet occurred.

In the pre-slipping stage where there was little if any deformity the treatment of choice was found to be drilling of the epiphyseal line in a manner similar to insertion of a Smith-Petersen guide wire. The drilling was then followed by pinning.

In cases suffering from acute slipping or fracture through the epiphyseal line, the best results were obtained in those who were seen immediately after the injury. In these cases, very gentle reduction followed by internal fixation by means of threaded Steinmann pins gave good results. If the accident was as much as two weeks old, it is inadvisable to attempt reduction, for the percentage of avascular necrosis of the epiphysis is extremely high.

Chronic slipping with minimal or moderate displacement; No attempt was made to reduce the displacement. Very good results were obtained by either simple avoidance of weight bearing, prolonged immobilization in plaster or by drilling followed by pinning of the epiphysis. In those treated by simple immobilization, nine months was the average time for closure of the epiphysis while those which were subjected to drilling and pinning closed in six months time. The internal fixation method has the additional advantage in assuring against an acute slipping from trauma.

Chronic slipping with marked displacement: From the present survey it is obvious that no matter what the treatment, the prognosis is poor. By drilling the epiphyseal plate and pinning the epiphysis, further displacement is prevented but an osteotomy is required to restore the proper weight bearing line. In the series presented, various types of osteotomies including cuneiform and subtrochanteric were used but the results were discouraging.

Residual deformities of the femoral head and neck due to old slipped epiphysis: All patients of this group complained of hip pain and had marked limitation of motion. The prognosis is grave in such cases and the only consideration is that of some type of arthroplasty or arthrodesis of the hip.

Mearns (11) reviews twenty-five cases (thirty hips) of slipping of the upper femoral epiphysis in the light of symptoms and diagnosis. The classification of the amount of displacement as seen on the AP and lateral x-rays is classified as: MINIMAL when the anteversional shift is less than one cm. and there is no vertical displacement; MODERATE cases with one cm. or more of anteversional shift but with slight or no vertical displacement; SEVERE displacements, those showing obvious displacements.

In the classification of the results the following criteria were used; Good, no pain or limp and a range of motion that does not in any way restrict normal activity; Fair, no pain and only a mild limp but with a limitation of the range of motion great enough to prevent participation in sports requiring running; Poor, pain on exertion or severe limitation of motion and shortening.

It is interesting to note that the frequency of involvement of the two hips was essentially equal but that the condition was found three times as commonly in the male as in the female, (76% male and 24% female). The vast majority of the cases were of the obese type and tending toward the Frohlich build.

No mention is made of the type of treatment employed but in the survey of final results, of the seven cases classified as minimal, all obtained good results. Of those classified as moderate slip (seven hips) only four could be classed as good and three as fair. Finally, of the sixteen hips in the severe displacement category, none could be classed as good, seven as fair and the remainder as poor. There is a direct relation between the outcome and the amount of slipping and, by the same token, to the promptness of diagnosis. Of the entire group the average age at the onset of symptoms was 13.5 years and the average duration of symptoms at the time of treatment was 8.5 months. All too frequently the admitting history was one of a child who developed mild pain without cause and a slight limp. He would be seen and x-rays made and the true pathology missed. The child's activities would be restricted and the symptoms would decrease. However, in a short period there would develop an exacerbation of the symptoms but with greater severity and the cycle would be repeated.

Mearns attempts to drive home the point that any child of the age group involved who develops pain in the hip either with or without injury should have a careful examination and thorough x-ray studies including the lateral view of the hip for it is on this projection that the early displacements can be found. It has been well shown that the so-called widening of the epiphyseal line is the result of anteversion which projected in the roentgenograph gives the impression of widening. The results of treatment of slipping of the upper femoral epiphysis are uniformly good when the diagnosis is made in the minimal slipping stage and the prognosis progressively more unfavorable corresponding to the severity of the displacement.

Samson and Jerry (12) report eight early cases of slipped epiphysis treated by Leadbetter reduction with plaster immobilization for three months using a Steinmann pin through the femoral condyles. In follow-up from nine months to three years the average shortening was $\frac{1}{2}$ to 2 cm. There was normal function in six cases, slight limitation of flexion in one case, and only one case of aseptic necrosis. Five late cases were treated by osteotomy with Steinmann pin or Blount blade-fixation. Four results were excellent and one fair.

Fischer and Leatherman (13) review the classical signs and symptoms of slipping of the capital epiphysis, emphasizing the often found early complaint of discomfort in the lower thigh and knee. Too many times x-rays are made of the knee and found normal and the patient dismissed. At that early period one has the optimum time for treatment of an early slipped femoral epiphysis.

The etiology of the condition is unknown. Some are associated with trauma. A striking number of the patients are obese, hypogonadal types of children.

Several types of treatment are reviewed. Some authors prefer merely plaster fixation in the early stage, i.e. with slipping of less than one third of the diameter of the neck, while others advocate fixation by means of a Smith-Petersen nail with no attempt at reduction. In the later cases with considerable displacement it is necessary to surgically replace the epiphysis, fixing it with a Smith-Petersen nail. A plea is made for early recognition, when the epiphysis is in the so-called "pre-slipping" stage and has migrated less than one third the diameter of the femoral neck. These early cases offer a good prognosis.

Hip Lesions in Childhood and Other Conditions

Hip lesions of infants and children seen at the Newington Home and Hospital for crippled children were reported by Heublein, Bernstein and Hubenet (14). They review embryological development of the hip and the relation of defects during the embryo stage to the deformities considered as congenital deformities as seen in the usual clinic for children. The importance of early diagnosis of the congenital conditions in relation to treatment and final outcome is stressed.

The various theories of the origin of congenital dislocation of the hip are noted and of the seventy-seven cases treated at the institution, the majority were in the female. Almost one third of the cases were bilateral. Forty cases were treated by closed reduction and thirty-seven by open reduction.

In the instance of congenital dislocation associated with arthrogryposis multiplex congenita, it is of interest that in this disorder quickening may occur late in pregnancy or be absent altogether. A presumptive intra-uterine diagnosis can be made on the basis of such a history and roentgen demonstration of the fetal extremities fixed in a position of extension.

The authors find that the incidence of congenital dislocation of the hip associated with spina bifida is quite rare.

Dislocation of the hip occurs in association with infective lesions of the hip and with infantile paralysis.

In cases of Legg-Perthes' disease, the authors review the literature and find the usual clinical and roentgen picture. It is noted that the widening of the epiphyseal line is of importance in early diagnosis. Fifty-nine cases of Perthes' disease have been treated during the previous twelve years. The average age at onset was eight years and males predominated over the female four to one.

The classical picture of slipped femoral epiphysis was noted in fourteen of the cases reviewed.

Other conditions of less frequency were myositis ossificans, achondroplasia and osteogenesis imperfecta.

Sadek (15) reports a case of a fourteen year old Egyptian male who sustained a laceration of the left thigh with a subsequent cellulitis and abscess formation. This was followed by a second abscess in the left arm some weeks later. While bedfast from these infections he developed flexion contractures of both hips and it was finally necessary to manipulate the left hip under anesthesia and apply a hip spica to overcome the contracture. The contracture was associated with pain and moderate swelling over the left sacroiliac joint and hip. Fifteen days after application of the cast, the patient developed frequency, dysuria, cloudy urine and pain in the region of the bladder. Urinary tract studies revealed a Staph. aureus infection and on passing a sound a foreign body of extreme density was encountered in the bladder. X-rays revealed a destruction of the left sacroiliac joint,

left acetabulum and proximal femur and a pathological dislocation. No evidence of any remnant of the head and neck of the femur was noted. There was seen a large calcified body in the bladder.

Through a suprapubic approach the bladder was opened and the head of the femur was found in the bladder. The wall of the bladder was intact. The patient made an uneventful postoperative recovery. All investigations for tuberculosis were negative. The author concludes that the femoral head had separated due to septic arthritis, and the same process involving the bladder wall allowed the head of the femur to enter the bladder and that finally the rent in the bladder healed.

In a study of the vacuum phenomenon in the hip joint Jerre (16) states that the radiographic visualization of a true "articular space" is rarely seen. It is recorded in the knee when it is forced into valgus as well as in the shoulder when the arm is stretched up and back as far as possible. It has also been demonstrated in the metacarpophalangeal joint when traction is applied to the finger. In all such cases the area or line of rarefaction of the true articular space disappears when the force used is released. The experiments of the author lead him to conclude that the forced position produced by abducting the tibia on the femur results in a negative pressure sufficient to cause a release of gas from the synovia. This gas, however, returns to its former state rather quickly after the vacuum is released.

The rarefaction, which was assumed to indicate the articular space, was observed in x-ray study of six cases of epiphyseolysis capitis femoris. Some men have indicated that such a phenomenon was characteristic of the condition. The author concludes that such an assumption is not justified. The presence of the finding merely indicates that the joint was simply placed in such a position as to create a vacuum at the time the film was taken. No pathological significance can be attributed to the finding and it is of only theoretical interest.

In a review of the innervation of the hip joint as presented in the accepted anatomical publications, Kaplan (17) finds that little has been added since the earliest of the present-day books and the information there given is based upon limited dissections. More recently experimental investigations have been carried out by a number of men in an effort to define the method of the production of pain in the hip joint. Sappey has reported that there are no sensory nerves supplying the synovia either in animals or man. It has further been determined that the sensibility of the capsule is great but quite different from the sensibility of the exterior parts. The ligaments were insensible to touch, compression, division and even cauterization in the living animal. However, as soon as the joints were submitted to torsion or elongation, the animal showed signs of pain.

It is obvious that at present, from the viewpoint of anatomy, many questions pertaining to the nerve supply of the hip joint are unanswered. The minute details are unknown, the histology of nerve endings is uncertain, the physiology of pain is not clear and the part played by the nervous system in the production of arthropathies is not entirely explained. It is unknown which area of the capsule is supplied by each participating nerve, how they overlap and what normal variations of supply occurs in a large number of patients.

Through the contributions of such men as Camits, Tavernier and others, the procedure of avulsion of the obturator nerve came in vogue as a means of relief of the pain in hips of patients whose debility allowed no extensive procedure or in whose case no other treatment was advisable. The obturator nerve had for years been known to supply fibers to the joint capsule and the joint, although the exact mode of the supply and the mechanism of the production of the pain were not known.

Since 1945, the author and his colleagues have performed the operation on fifty-four patients. The surgery is preceded by a novocain injection test to determine the amount of relief from a temporary anesthetic of the nerve. The technique of the injection is as follows: With the patient flat on his back, the leg is abducted to bring out the adductor longus. A 22 gauge 2 inch needle is introduced near the insertion of the adductor longus close to its lateral border and pushed down to the horizontal ramus of the pubis. As soon as the bone is reached the point of the needle is deflected down under the horizontal ramus and pushed about 1-1.5 cm. into the foramen. Ten cc. of 1% novocaine without adrenalin is injected. Relief of pain by the injection is considered an indication for the surgical avulsion of the nerve.

In the surgical avulsion of the nerve, the author utilizes an approach through the femoral triangle and the nerve is avulsed at its exit from the foramen. He objects to the suprapubic approach of Chandler as more difficult particularly in the obese patient.

The end results in the fifty-four patients operated were: ten patients had an excellent early and late result; seven had a good result; nineteen were improved; seven had no improvement; in eleven cases the information is incomplete. Thus, there was a general improvement in about 67%.

Heilbrun (18) points out that the large number of paraplegic patients resulting from World War II serve to emphasize the occurrence of soft tissue calcification and erosive bone lesions in the pelvic region of such patients. The soft tissue calcifications are most frequent about the hip joint but may occur in any muscle or tendon. The most common site of occurrence is about the superior border of the greater trochanter. The next most common site is in the fascial planes of thighs and buttocks.

Erosions are noted in the greater trochanters when associated with decubiti over the trochanters. There is a loss of configuration of the trochanter, and it becomes flattened. Following the healing of the ulcer, there is a partial restoration to normal shape of the bone. Three cases are presented as illustrations of this condition.

Pathological Dislocation

Due to the fact that cartilage undergoes rapid solution in pyogenic exudates Bryson (19) states that the condition of suppurative arthritis in the infant is an entirely distinct condition from suppurative arthritis at any other age. There is a rapid destruction of the cartilaginous head in children with pathological dislocation of the hip. In the older age groups

the process results in a destruction of the cartilage until there are raw bone surfaces opposed and then fusion takes place rather than dislocation. The desired objective in the treatment of suppurative arthritis in the infant is to obtain a stable, moveable, painless joint with a limb of as near normal length as possible.

The article is based upon a survey of seventeen cases treated by various methods including one reconstruction of the Colonna type, four subtrochanteric osteotomies, eleven arthrodeses of the hip and one case not as yet surgically treated. The follow-up period averages ten years.

The one case of Colonna arthroplasty was a failure due to redislocation. Of those treated by subtrochanteric osteotomy, three of the four were failures. The author finds the osteotomy helpful in realigning the limb after arthrodesis but a failure when performed primarily. The arthrodesis was by far the most successful procedure in reaching the desired criteria as nearly as possible even though motion is sacrificed. Of the eleven cases treated by fusion, seven united within a few months and the remainder after a second attempt. Failures are thought to be due to the fact that the patients were operated on at too early an age and required a second procedure.

In the arthrodesis group there was only one case that noticed back pain in later life and in this instance the discomfort was trivial. The optimum time for arthrodesis is between the ages of twelve and fifteen.

Traumatic Dislocation

Stuck (20) states that the circulatory damage resulting from dislocations of the hip make this injury one of the most crippling. From 30-50% of those sustaining this injury, suffer late symptoms such as pain, limp and stiffness. Although the injury has been recorded since the time of Hippocrates, it was not until of late years that the extreme importance of prolonged and guarded aftercare was appreciated. The precarious blood supply to the head of the femur makes dislocation, with its inevitable disruption of this supply a major injury. The treatment should be a reduction under general anesthesia performed with gentleness. After the reduction of a simple dislocation, the patient should be in bed for two to three weeks and then gradually allowed up on crutches. No weight bearing should be permitted for at least six months. In those dislocations associated with fracture of the acetabulum, the convalescence will be prolonged for it will be necessary to apply post reduction traction in some while in others, surgical replacement is required. After the patient begins weight bearing he should be followed every two to three months by x-ray examination and at the earliest hint of necrosis of the head weight bearing must be discontinued.

Armstrong (21) reviews 100 cases (101 dislocations) of the hip in the light of treatment and end results. The accidents were sustained principally in the service during the recent War.

Regarding the method of sustaining the injury it was found that eight were due to wide abduction, ninety-three to a force acting in the long axis of the femoral shaft such as sustained in the crash landing of planes with the knee forced against the front of the cockpit. Generally it was observed

that if the hip joint is flexed and adducted, the force applied in the long axis of the femur will produce a simple posterior dislocation through the area in which the capsule is relatively weak and the acetabulum is shallow. If the flexion and adduction are less there is a resulting dislocation complicated by fracture of the rim of the acetabulum. If the hip is abducted and more or less extended a central fracture dislocation of the acetabulum will be produced.

The following types of dislocations were sustained in the cases surveyed: forty-six cases of simple dislocation, forty-three cases of dislocation with fracture of the rim of the acetabulum, seven cases of dislocation associated with a fracture of the floor of the acetabulum, and five cases of dislocation complicated by fracture of the head of the femur.

In the treatment of simple dislocations, the hip was reduced under general anesthesia and immobilized in a plaster spica for eight weeks. This was followed by a period of four weeks of no weight bearing on crutches and thereafter the patient was treated at a rehabilitation center four to six weeks. Complete recovery was found in 76% of the cases followed. One patient was found to have an avascular necrosis of the head of the femur forty-one months after injury.

Of those sustaining dislocation with fracture of the rim of the acetabulum 65% were judged to have made complete recovery. Nine patients developed arthritis and one patient avascular necrosis. In the treatment of these cases, the majority required only manipulative reduction to replace the dislocation as well as the fragment from the rim of the acetabulum. In those in which the fragment remained displaced it was found that the vast majority could be replaced by placing the limb in skeletal traction for five or six weeks. All were then immobilized in a spica cast for at least eight weeks or until the fragment had united. In a few isolated cases, it may be necessary to resort to open reduction of the fragment. Sciatic nerve paralysis occasionally results from the pressure of the displaced fragment and it is necessary to speedily reduce the fragment and alleviate the pressure on the nerve.

In the cases of dislocation associated with fracture of the floor of the acetabulum, the dislocation can, and was, usually reduced without difficulty with traction. However, even then the results are uniformly disappointing. Of the three central dislocations, two resulted in ankylosis and the third in severe and painful arthritis. The four posterior dislocations with fracture of the floor of the acetabulum all resulted in arthritis with pain and loss of motion. The author feels that the treatment of such injuries is early arthrodesis of the hip.

Of the five cases sustaining dislocation with fracture of the head of the femur, two obtained good to normal hips and the remaining three had poor hips.

Parker (22) gives a review of the literature regarding traumatic posterior dislocation of the hip and a discussion of complications and usual associated injuries. The more common complications are fracture of the acetabular rim, fracture of the femur, sciatic nerve injury and aseptic necrosis of the femoral head. The more widely advocated measures for reduction of

posterior dislocations of the hip are discussed and the method of simple traction by block and pulleys is presented. Two schools of thought are generally recognized so far as treatment of such dislocations is concerned: (1) Reduction by manipulation---for example Bigelow's method; (2) reduction by traction and countertraction. The author favors the second group. The method presented places the patient on a Hawley table which is locked. The peroneal post affords the countertraction element and by using skeletal traction forceful pull is applied through the use of pulleys anchored to the wall. The method has succeeded in cases in which other means have failed and has never failed to afford reduction quickly. It is a useful procedure in cases of rather long standing posterior dislocation and a case is presented in which such dislocation had been present three weeks.

After considering the results of the usual stereoscopic films of the pelvis and both hips in simple dislocation or fracture dislocation of the hip, Hunsberger (23) advises an additional view, a direct lateral view of the entire pelvis. This may not be possible in severe pelvic fractures but in cases in which the patient can be safely positioned on the side, the additional view will often give valuable information as to the displacement of the femoral head more accurately than can be obtained by the usual stereoscopic views. Examination of the patient in bed by the use of a portable machine has not proved satisfactory.

Arthroplasty

Smith-Petersen (24) in delivering the Moynihan lecture for the year gives a resumé of the origin and progress in the field of mold arthroplasty. The original concept of the approach, now bearing his name, arose from the surgical training gained from observing Cushing's neurosurgical technique in the cerebellar approach. The approach to the hip, for the first time allows adequate exposure so necessary for the proper reconstruction of the joint in the use of the mold arthroplasty.

An opportunity was afforded the author to study a piece of glass removed from the back of a patient in 1923. It was found to be surrounded with a glistening synovial sac. The idea dawned that such a thing might be applied to arthroplasties. In the same year a cup or mold of glass was used in the reconstruction of a hip. The result was good until the mold broke. This led to further studies and from that time other materials such as viscaloid, pyrex, bakelite and finally vitallium were employed in the manufacture of the molds. Since the original inception, over 500 hips have been operated upon by this method at the Massachusetts General Hospital. These reconstructions were performed for such conditions as malum coxae senilis, rheumatoid arthritis, complications of fractured hips, congenital dislocations and other less common conditions. It is noted that the results in the cases of malum coxae senilis were generally quite satisfactory but those obtained in the cases of rheumatoid arthritis were only encouraging. However the means certainly justified the outcome even when only a small amount of painless motion could be obtained in an otherwise solid hip. It has been found necessary to revise the first arthroplasty in fifty-three cases for various reasons such as errors in early technique, bony proliferation about the cup, post-operative sepsis and for enlargement of the acetabulum.

Law (25) reviewed a group of 150 vitallium cup arthroplasties. Of the 150 patients there were 182 hips which had been so reconstructed. There were a number of types of pathology for which the procedure had been carried

out. More than half the cases were less than two years postoperative.

In cases of old congenital dislocation of the hip, twelve patients had unilateral arthroplasty and four bilateral. The average age at time of surgery was thirty-four and a half years. Two postoperative dislocations occurred which were corrected by deepening the acetabular socket. One case of sepsis will require a future revision. Finally it may be said that of the series reported, all but three of the procedures were quite satisfactory. This type of case is considered one of the most favorable for arthroplasty.

Forty-five cases were treated for complications of femoral neck fracture. Of the group, thirty-five were considered satisfactory and ten unsatisfactory.

Arthroplasty for septic arthritis: There were 27 patients (34 arthroplasties in the group.) Such procedures should be attempted in the late stages and well after any evidence of activity has subsided but even then there is danger. Four cases were complicated by infection and two cases required revision due to bony overgrowth. The range of motion gained in these cases is not as satisfactory as in traumatic and noninfective cases. Of the group 25 were considered satisfactory and nine unsatisfactory.

Arthroplasty for rheumatoid arthritis: There were 26 patients (42 arthroplasties.) In the final analysis, 33 were considered satisfactory and nine unsatisfactory. A total of 13 of the cases required secondary revision for bony proliferation or some other reason. Of the entire series the final result was less perfect in this condition than in any other. The range of motion was decidedly less in this group. It would appear that a fair percentage of them were in the "satisfactory" class but many of those in this group which were considered satisfactory would not ordinarily have had such a classification. The author calls attention to the fact that some were bedridden prior to surgery and now can walk. This in itself, regardless of some restriction of motion would make the result seem satisfactory.

No strict limits are set by the author for his classification of "satisfactory" but an estimated value is placed on the result considering the original disability and end result. Measurements of motion are made. As previously stated, a result may be considered good when appearing in one group but poor if the same result was obtained in another i.e. the amount of original disability has a profound result on the final classification.

In summary, the author feels that 80% of the entire group of 182 arthroplasties are satisfactory.

Naden (26) reports end results in 36 arthroplasties performed on the Orthopaedic Service of the Vancouver General Hospital. On the whole the results were gratifying in cases of osteoarthritis of the hip, but very poor in rheumatoid arthritis. Twelve patients showed good or fairly good results; seven were fair. All four rheumatoid cases were poor. Five patients had since died. Nine were gainfully employed in work ranging from brick laying and land clearing to short-hand-typing. Five were housewives doing light to full housework. Except in the case of rheumatoid arthritis, results were better than had been expected and arthroplasty was to be recommended in patients of the older age group as a procedure of less magnitude than arthrodesis, offering good possibility of improvement.

Fitzgerald (27) describes a modified Leadbetter osteotomy consisting of an anterior approach at the junction of the upper 1/3 with the lower 2/3 of the neck. The outer fragment of bone is then divided inward as far as the fracture line. The new lower fragment is displaced medially and with force so that it rotates the head of the femur and comes to lie beneath it. This author has utilized the procedure with the following modifications; a lateral approach is made using x-ray control. The osteotomy has been made at a lower level (junction of lower 1/3 with upper 2/3) to facilitate displacement of the shaft and rotation of the head. Six cases have been treated by this method with good results.

A method of subtrochanteric osteotomy is presented by Lippman (28) with the advantage over the usual type of osteotomy in this region in that the danger of slipping is eliminated without the disadvantage of the insertion of some form of internal fixation. Technique: A lateral approach is utilized and a subperiosteal exposure carried out for two to three inches below the vastus ridge. The osteotomy commences just at the ridge and terminates medially just below the lesser trochanter. The leg is adducted and the fragments distracted. A cavity is then curetted in the proximal fragment to a depth of one-half to three-quarters of an inch. The obliquely cut end of the distal fragment is then shaped into a spike by the use of a rongeur. The spike is fitted into the cavity of the proximal fragment and the leg adducted to lock it into position. It may be necessary to shorten the spike somewhat to obtain the position desired. The desired amount of abduction and rotation are secured easily and the leg immobilized by the use of a plaster spica.

Due to the fact that in the abducted position the fragments are impacted and locked, it has been found possible to remove the spica cast, in some cases, at the end of two weeks time, substituting bilateral long leg casts connected by a bar to maintain abduction and still allow no danger of slipping of the fragments.

Aseptic Necrosis

Jackson and Bickel (29) report an unusual case of aseptic necrosis of the head of the femur following a minor fracture of the greater trochanter. A sixty-four year old male sustained a fall on his knees and then rolled onto the left side. At the time of the injury he experienced some pain in the knees and the left hip but was soon able to arise and walk seven blocks to his place of employment. The pain became more severe with the passage of time and he was seen because of severe pain in the left hip. Examination revealed a fracture of the greater trochanter with little displacement of the fragment. He was treated by rest in bed and made an uneventful recovery. He was discharged from the hospital thirty-two days after admission with instructions to remain on his crutches. These were eventually discarded, and the patient noticed no discomfort. He was seen on numerous occasions in the following weeks with the x-rays finally showing healing of the fracture. He was again seen twenty-four months after the injury and at that time roentgenographic examination revealed a typical aseptic necrosis of the head of the femur. He was treated by no weight bearing on crutches. The follow-up was terminated with the sudden death of the patient from a ruptured aneurysm of the abdominal aorta.

The authors review the accepted anatomical facts regarding the blood supply to the femoral head and concur that the principal source is through the capsular vessels and the vessels in the ligamentum teres. The etiology of this patient's trouble cannot be determined unless there was a thrombus in the vessels supplying the hip. There was no fracture to produce the interruption of the blood supply.

Chandler (30) states that infarction of the head of the femur in the clinical sense is a group of symptoms, dominated by pain, loss of function and bony collapse caused by deficiency in arterial nutrition of the head of the femur prolonged enough to result in marked degeneration or even necrosis of bone. The condition occurs two or three times as commonly in men as in women and usually between fifty and seventy years of age.

A clear comparison is possible between the heart and the femoral head. The heart lies in the pericardial sac much as the head of the femur lies in the synovial lined capsule of the hip joint. The blood supply is similar, in that the vessels are really end arteries in each case and similar in their gross anatomical configuration. Impairment of circulation, due to vascular obstruction from any cause, is followed by degenerative changes in either myocardium or bone. The degree of degeneration and the effectiveness of repair depends upon the extent of the vascular impairment and establishment of an adequate collateral circulation.

In the head of the femur, because of its bony composition, degenerative changes are delayed in their appearance either grossly or on x-ray. Likewise repair is a slow process and accomplished through what Phemister describes as "creeping substitution."

The terms coxae malum senilis and aseptic necrosis merely describe the condition at a given time but convey no meaning nor understanding of the foregoing basic pathology. It is the author's hope that a more widespread and clear understanding of the concept of "coronary disease of the hip" will throw more light on our knowledge of many pathological processes of the hip joint.

An attempt is made by Badgley and Denham (31) to first limit the terminology now in use regarding "aseptic necrosis" and "avascular necrosis". True, much confusion exists in the literature so that for the purposes of this article the terms are given their boundaries. Avascular necrosis is defined as death to part or all of the head of the femur due to vascular damage primarily of the posterior and anterior circumflex femoral arteries. Aseptic necrosis is used to denote a process of repair, a dynamic time period in which the death of a part of the head is incomplete. It involves the potential collapse of the remaining untransformed portion of the head or the possible development of a degenerative arthritis. It is a descriptive term for the cartilage changes, necrosis and the loss of joint space.

It is found that 40% of the cases of fracture of the neck of the femur which are treated by internal fixation and in which bony union is successful are followed by the development of avascular necrosis. The authors are in agreement with Watson-Jones that internal fixation itself has no bearing upon the development of avascular necrosis in these fractures.

In the treatment and prevention of avascular necrosis, care must be taken to avoid further injury to the blood supply of a hip already fractured. Rough handling in transport may further damage the vascular supply. No forceful manipulation should be employed in the reduction of the fractures. It is felt that the treatment should be instituted as early as possible and that a delay of two weeks certainly leads to a poorer prognosis than in the case nailed at once. Open reduction should be avoided if at all possible for this can only damage the already precarious blood supply to the head. No weight bearing should be permitted for at least six months.

Avascular necrosis of the head of the femur may lead to 1. complete reformation of the head to a vital functioning structure, 2. aseptic necrosis, 3. degenerative arthritis, or 4. nonunion.

Arthrodesis

Simmonds (32) reports a case of a twenty year old white male who developed osteomyelitis of the pelvis at the age of twelve. This was followed by fusion of both hips. The left hip fused in ten degrees adduction, neutral rotation and twenty degrees flexion. The right hip fused at twenty degrees abduction, forty degrees external rotation and fifty degrees flexion. With hips fused in these positions, the boy can easily walk five miles, dance as well as run up and down stairs. There is no discomfort. In view of this case the author raises the question as to whether one is justified in fusing hips in the customary almost full extension and whether it might not be advisable to flex one hip twenty degrees and the other forty to fifty degrees for purposes of ankylosis.

Langston (33) has utilized the Brittain method of arthrodesis of the hip in 28 cases and from these, draws certain conclusions, presents a few cautions and describes three modifications of technique which he feels facilitates the procedure.

Regarding the principles of the procedure: (1) It allows a true extra-articular method of arthrodesis away from the disease process in the hip. (2) Deformities can be corrected at the time of surgery and this may eliminate the necessity for a second operation. (3) The removal of the pull of the adductors will frequently in itself result in improvement in the pathological process in the hip joint. (4) The minimum age considered advisable for the procedure is ten years.

A few of the more important disadvantages are (1) The constant danger of damage to the sciatic nerve, (2) The fixation of the graft in the ischium is necessarily blind and at times fails to make contact or may fail to be firmly fixed in the previously made cut in the ischium, (3) Cases are known in which a misdirected graft not only damaged the sciatic nerve but in one instance perforated the external iliac artery, (4) In the five failures in this series, all were the result of failure to properly place the graft in the ischium.

The insertion of a guide wire under x-ray control prior to beginning the osteotomy is considered advantageous. Also the femoral osteotomy must be a clean cut and care taken to avoid leaving a spike on the inner cortex of the femur which will prevent proper medial displacement of the shaft.

Brittain (34) outlines in detail the operation of ischio-femoral arthrodesis which he described first in 1941. It is admitted that this form of arthrodesis is not feasible in all hips because the diseased process occasionally involves the ischium.

The technique is as follows: With the patient on an orthopedic table two skin clips are placed over the head of the femur. A calibrated guide is inserted on the anteroinferior aspect of the shaft and neck of the femur. An x-ray is made. While this is being developed a tibial bone graft is cut. It is preferable to take the graft from the affected limb in order that the sound limb may have full strength for convalescence. It is essential to cut a wide tibial graft. The whole basis of the ischio-femoral arthrodesis is the use of a wide tibial graft, which is more certain to engage the ischium. The graft should include the posterolateral and posteromedial borders of the tibia. Beginning one inch above the greater trochanter a curved incision is made, with the convexity upwards, and is carried four inches below the trochanter. The shaft of the femur is exposed. A site for the osteotomy is chosen, bearing in mind that the lower limit of the greater trochanter is a point which is easy to verify, and that the skin clips are an additional guide. A small hand drill is introduced through the femur at an angle of forty-five degrees in the coronal plane. After the inner wall of the femur has been pierced, there is a lack of resistance until the ischium is struck. An x-ray is then made to verify the position of the drill. A subtrochanteric osteotomy is performed. Special chisels are used with screws to separate them; one chisel with a slot and shoulders receives the other. After the osteotomy has been performed by one chisel (the male) it is tapped inwards until it engages the ischium. An x-ray is then taken for position and the other chisel is then introduced below the first. The chisels are separated widely by means of the screw provided and thus a V-shaped slot is made in the ischium. The male chisel is then withdrawn. The graft is tapped along the remaining chisel. As the graft is tapped, the chisel is withdrawn. When the graft is felt to engage the ischium, it is tapped solidly home. The distal fragment of the femur is then displaced medially until it makes contact with the ischium, thereby supporting the middle of the graft.

The author has performed the operation 105 times on ninety-five patients with eighty-two successful fusions. These procedures have been carried out for tuberculosis of the hip, osteoarthritis and infective arthritis.

Of the important complications, striking the sciatic nerve is prominent. It is felt that if the chisel is kept in the horizontal plane and the hip is not flexed this danger is not great. Hemorrhage is to be guarded against. This most often can result from misdirection of the graft on the chisel and damage to the obturator artery or branches of the lateral femoral circumflex artery.

The reasons given for failures are: (1) passing the chisel or the graft through the obturator foramen, (2) nonunion between the osteotomized fragments or between the graft and the femoral fragment at the outer end and (3) extension of the disease into the area of the graft.

At the time of writing, L. Mayer (35) states that no cases of injury to the sciatic nerve during the Brittain operation have appeared in the literature although they are known to have occurred. Due to the close proximity of

the sciatic nerve, cases are sure to occur. The author presents a case of a woman suffering from tuberculosis of the hip. A Brittain type fusion was carried out as usual with no operative or immediate postoperative difficulties. However as soon as the patient regained consciousness, there was noted complete loss of sciatic nerve function in the foot. The lower portion of the cast was removed to eliminate the possibility of pressure on the peroneal nerve but such was not the causative factor. After neurosurgical consultation, an exploration of the sciatic nerve was carried out. As soon as the sciatic nerve was exposed there was a sudden gush of dark blood from a large hematoma which completely surrounded the nerve and infiltrated it. The nerve was freed and at no place was it found to have sustained direct injury. The tibial graft had passed $\frac{1}{2}$ inch from the nerve and it was the bleeding of the soft tissues incident to this placing of the graft that had produced the hematoma. The nerve was transplanted. The patient made a gradual recovery and obtained good fusion of the hip although at the time of writing she still had not regained all sciatic nerve power and was wearing a brace. It is of interest further to note that nine months following surgery the patient apparently with little or no trauma suffered a fractured tibia at the site from which the graft had been taken. Furthermore, Mayer estimates that 50 to 70% of the cases operated at the hospital have incurred such a fracture.

The author favors the mechanics of the Brittain operation but feels the posterior approach as utilized by Trumble and at the Massachusetts General Hospital should replace the "blind" insertion of the graft. In addition, such an approach would allow the use of iliac grafts or smaller tibial grafts and eliminate the complication of tibial fracture.

Karlen (36) reviews cases of arthrodesis of the hip by nailing process performed between 1938-1946. There was a total of 95 operations; five patients had a second operation. Mortality rate of the group was 5.3%. The first eighteen fusions utilized the regular three flanged nail driven well across into the acetabulum. Of this group, eight showed slipping of the nail. However, final analysis showed three of the eight had solid union and one had a fibrous ankylosis with good clinical result. The simple three flanged nail was then replaced by a fenestrated nail. Also the simple extra-articular arthrodesis gave way to a transarticular arthrodesis combined with intra-articular arthrodesis. A total of forty cases had fixation with the fenestrated nail. Twenty-seven of these had simple transarticular nailing and thirteen the combined procedure. Although the use of a fenestrated nail eliminated the complication of slipping, twelve nails broke at one of the fenestrations. Four of the twelve went on to bony ankylosis. The postoperative period was merely bed rest and no fixation by plaster, a fact accounting for a major part if not all fractured nails.

The author's statistics reveal a rather high incidence of fibrous union in those cases treated by simple transarticular nailing without intra-articular arthrodesis (20 of 43 cases). In the same group there were eight cases with no union. When the intra-articular procedure was added, a much better result was noted (16 bony ankylosis in 21 cases). The author contends that mere x-ray evidence of fibrous union is not a particularly condemning item since 82% had clinical ankylosis and a good result when all cases are considered as a group. Irrespective of nail type or use of intra-articular procedure the results show 50.6% bony ankylosis, 31.5% fibrous union, 11.2% non-union and 5.7% deaths.

This type of arthrodesis has the distinct advantage of reducing the postoperative period of recumbency. The average period was only 3.2 weeks in the simple transarticular nailing (fibrous union high) and 9.9 weeks in the combined type of procedure.

Developmental Coxa Vara

LeMesurier (37) discusses developmental coxa vara, based upon fifteen cases seen at Children's Hospital, Toronto. During the same length of time one hundred ninety-seven congenital dislocations of the hip were seen. This illustrates the relative infrequency of this condition. A case in an adult is also included. There was a familial tendency noted as four of the patients were related.

Usually the limp or waddle appeared at three or four years of age, after preceding normal ambulation. There was no relation to injury. Late secondary arthritic changes brought the adult case to seek treatment at the age of forty. Examination quite uniformly reveals limitation of motion at the hip primarily in abduction. There was marked uniformity of x-ray findings characterized by a triangular bony defect distal to the capital epiphysis, on the inferior border of the femoral neck, associated with a variable degree of coxa vara. The author feels that these x-ray findings are in themselves diagnostic. There were bone changes seen distal to this defective region. These were essentially those of variation in bone density of an extreme degree resembling fragmentation. The author believes that the defect is cartilage which has incompletely ossified and the bending of the neck occurs from this structural weakness.

Attempts at correction of the coxa vara by traction were unsuccessful. Abduction osteotomy between or below the trochanters gave satisfactory results in twelve hips with improvement of the weight-bearing mechanics and healing of the neck defect within a year. All osteotomies healed without incident. Three cases seen early and before coxa vara deformity was pronounced were treated by cortical grafting through the neck into the epiphysis through a drill hole placed from the lateral femoral surface. These three cases showed evidence of healing of the femoral neck defect three to four months postoperatively, without coxa vara occurring or progressing. One case treated by closed nailing with a Smith-Petersen nail failed to show healing of the neck defect.

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SECTION 14

CONDITIONS INVOLVING THE KNEE JOINT

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1. Arthrography - Meschan and McGaw (1) compare the arthrographic and operative findings in 315 knees which were operated upon from 1942 to 1945. They found their results 81.6% accurate and of particular value in diagnosis of abnormalities of the menisci, fat pads, and bursae. They have found the procedure to be without risk and use it in all cases of suspected internal derangement of the knee.

Colonna (2) describes the differential diagnosis of intra-articular lesions of the knee joint, specifically traumatic arthritis, hypertrophied fat pads, intermittent hydrops, internal derangements, loose bodies, synovial tumors, tuberculosis, and Charcot joints. He discusses the etiology and the treatment of these conditions.

2. Anatomy - Gardner (3) studied the nerve supply to the human knee joint by making serial sections and reconstructions of fetal joints and by dissecting adult joints. He has considered the femoral nerve, the tibial nerve, the common peroneal nerve, and the obturator nerve. There are 14 articular branches from these four nerves and he has traced them to the portion of the joint that they innervate. The only specificity that he has demonstrated is that the branches of the femoral nerve supply the suprapatellar recess and the patellar periosteum and that those of the common peroneal nerves supply the tibial tuberosity. All other areas he described are supplied by the articular filament of at least two of these large nerves. He notes a concentration of fibers in the posterior capsule, suggesting that it may be a center of proprioception. (Ed. Note: This study appears to be of little clinical value because of the lack of specificity of innervation of these articular branches. For example, articular filaments of all four of these large nerves supply the infrapatellar fat pad. The concentration of fibers in the posterior capsule, which he describes, is presumably not the subsartorial plexus).

Last (4) reviews the anatomy of the knee joint capsule and accessory ligaments, the intra-articular structures, the movements of the knee, and the muscle attachments near the knee joint. He reminds us that the medial ligament is not a ribbon, but a broad, flat triangle, which extends posteriorly along the joint line and down the tibia the breadth of a hand. He describes how the fetal capsule perforates when the infant walks and thereafter communicates with the suprapatellar bursa. He describes the cruciate ligaments as being "wound up" by lateral rotation of the flexed tibia and "unwound" by medial rotation. He explains how the popliteus muscle pulls the lateral cartilage back out of harm's way when the flexed tibia is

rotated laterally by the hamstrings. He shows that the last part of full extension of the knee is lateral rotation of the tibia, because the shorter lateral femoral condyle is "used up" first; and how flexion movement is begun by the popliteus by medially rotating the tibia, thus being the antagonist of the lower fibers of the vastus lateralis. There are six drawings to illustrate this article.

Helfet (5) gives his conception of the function of the cruciate ligaments. He feels that they act as guide ropes, rather than check ropes. The anterior cruciate pulls the tibia into lateral rotation on terminal extension, which is necessary for stabilization in this position. Bucket-handle tears of the medial meniscus block lateral rotation and result in limitation of extension until the ligaments are stretched so that full extension is obtained without lateral rotation. The author transplants the patellar tendon medially for anterior cruciate weakness which increases lateral rotation of the tibia in flexion. The posterior cruciate ligament rotates the tibia medially when the knee is flexed. Surgical treatment of relaxation of this structure consists of transplanting the semitendinosus tendon into a groove on the medial femoral condyle, which, he states, increases the medial rotation of the tibia in flexion. He reports five cases of surgically treated cruciate weaknesses, in which the abnormal movement was still present at rest, but which had increased knee stability in walking. This he attributes to a return toward normal tibial rotation.

3. Deformities - Smillie (6) describes the anatomical and pathological features of 29 congenital discoid menisci which he encountered in his personal series of 1300 meniscectomies. He classifies these 29 cases and compares them with those of the cases previously recorded in literature. He found one case of medial discoid cartilage and compared it with the only other case known to be recorded. He recognizes three anatomical types of discoid cartilages and describes them as follows:

a. Primitive type: (15 cases) This type shows early cessation of any intention of becoming a meniscus. It has a thick medial border.

b. Intermediate type: (8 cases) It is less massive, has a thin central zone and a thin medial border.

c. Infantile type: (6 cases) It is more like the normal structure, but has a broader central portion.

He gives the characteristic lesions of each type in detail.

Hamilton (7) feels that the non-rachitic cases of genu valgum are due to lack of muscle tone and that stretch of the internal lateral ligament is secondary. He urges that children with poor muscle tone be taught early to use their muscles, even at three months of age. If the condition is present at 15 to 18 months he uses an elevation on the medial side of the heel in addition to the exercises.

Wagner (8) writes of seven cases of fixed extension of the knee, varying in age from 24 to 47. Four followed open operations of femur fractures;

one was due to GC arthritis; and two due to synovectomy following synovitis. He describes his method of capsulotomy and quadriceps lengthening and emphasized physiotherapy and reconditioning. His best results took two years to obtain.

4. Infections - Gordon and Shechter (9) report a case of salmonella suipestifer (hog cholera bacillus) infection of the knee joint and review the literature reporting these infections in humans. The patient was a 38 year old negro male who showed clinical improvement on the third day of streptomycin therapy and made a complete recovery in three months.

Harris and Meyers (10) tell of a case of the same infection in the knee joint of a soldier in Italy, 20 days after a compound fracture of the midshaft of the tibia and fibula. Sulfadiazine and penicillin with arthrotomy resulted in recovery. The end result was not known.

5. Cysts and Ganglia - Moore (11) reviews three cases with popliteal varices that pre-operatively were diagnosed as Baker's cysts. All three cases responded well to surgical excision. The author could find reports of only two other cases of popliteal varices in the literature.

Levine (12) describes the third case of ganglion of the anterior cruciate ligament in the literature. His case was associated with osteochondritis of the patella and he discusses theories of pathogenesis of this ganglion. He states that his is the first case reported in the English literature.

6. Injuries, Prevention of - Quigley (13) recommends measures to reduce knee injuries in football players. Those players with history of previous knee injuries, operations, or instability are strapped with adhesive before each practice session and game. The "Duke-Simpson" strapping is used and its application is described.

7. Injuries, Fractures - Cave (14) discusses the mechanism of fractures of the tibial condyles and the associated injuries to the ligaments and menisci. He feels that fractures with little displacement and severe fractures of both condyles are best treated by closed manipulation and traction. Depressed fractures of one condyle are treated by open reduction. He describes the procedure in which fragments are replaced and held with a long bolt. Repair of torn cruciates and collateral ligaments is not carried out. If fragments are able to be fixed well, early exercises are started in a hinged brace with weight bearing in two to six months.

8. Injuries, Internal Derangements - McMurray (15) reviews the anatomy of the knee joint, the symptoms of internal derangement, the conservative and operative treatment, and the differential diagnosis. He stresses conservative treatment of all ligamentous injuries, with immobilization in 15 to 20 degrees of flexion for two to three months.

Lipscomb and Henderson (16) present a study of 664 arthrotomies for internal derangement done at the Mayo Clinic. The diagnostic triad of locking, pain, and swelling was present in 70 per cent of the cases. Associated lesions of the ligaments or of the patella give poor prognosis. These authors believe that surgeons not greatly skilled in meniscectomies should remove only the anterior or torn segments, and that if the whole meniscus is removed, it should be done through two incisions. They view

with skepticism the diagnoses of hypertrophic fat pad and fibrillated or loose cartilage as the cause of symptoms.

Peabody and Walsh (17) discuss at length the diagnosis of knee joint derangement illustrating with typical cases. They believe chondropathy of the patella has a higher incidence than any other internal derangement. They restate their belief that patellectomies should be done in some cases of traumatic chondritis of the patella, in severe traumatic types, and in the presenescent type, but that resurfacing of the patella is the treatment of choice in the chondromalacia type and in younger persons. They describe an approach for meniscectomy which they believe gives greater exposure with less trauma. A parapatellar incision is continued down to the joint line where it curves medially to the anterior fibers of the collateral ligament "a few inches below the joint line." The capsule flap including synovia is dissected subperiosteally and retracted medially. The meniscus is removed from before backwards as usual.

10. Injuries, Late Changes - Norley and Coventry (18) add 12 cases of calcification of the meniscus to their previous nine. Two types are described -- the primary type with calcium throughout, starting at the periphery, are usually multiple and probably due to nutritional and degenerative changes. The secondary type show local deposits, involve a younger group of patients and are due to trauma. Most symptoms were of long duration. Three received surgical treatment and complete cure while the remainder improved on heat, rest, massage, and elastic support. Calcium was found in all three surgically treated, but there was no ossification.

Ghormley (19) discusses results to be expected as late changes in joints which are the site of internal derangements of various sorts. Many of these may be minimized or prevented by early removal of loose bodies, torn cartilages, and other damaging structures. In other cases, synovectomy may be necessary to relieve the condition. In many cases, however, much can be done to prevent the damaging development by advising the patient of his condition, by showing him how to develop muscular stability of the joint by means of exercises, and by teaching him to avoid the more strenuous activities. Patients should also be taught to avoid excess weight, a very important factor in many cases.

Fairbank (20) made an investigation of changes in the knee joint from three months to 14 years after meniscectomy and found three types of changes, excluding osteoarthritis. They are:

a. Ridge formation on the femoral condyle; b. Narrowing of the joint space; c. Flattening of femoral condyle.

<u>Operation</u>	<u>Total Cases</u>	<u>No Change</u>	<u>Ridge</u>	<u>Narrowing</u>	<u>Flattening</u>
Medial Meniscectomy	80	33%	43%	32%	18%
Lateral Meniscectomy	27	50%	7%	40%	17%

(Narrowing plus flattening were the commonest changes found in combination)

The author suggests that these changes result from the loss of the weight bearing function of the meniscus and describes an ingenious mechanical proof of this function. He contends that meniscectomy is not fully innocuous, but is unable to establish a connection with later osteoarthritis definite enough to justify clinical deductions.

Haldeman and Soto-Hall (21) discuss the importance of the articular cartilage in knee joint lesions. The etiology of chondromalacia and osteochondritis dissecans is reviewed. The early surgical correction of lesions involving articular cartilage is stressed.

11. Surgery, Meniscectomy - Charnley (22) in considering the causes of unsatisfactory results of meniscectomies during war time, suspected vertical and oblique scars as being the source of slow recovery and post-operative effusion from "scar friction". One scar, markedly nodular, was removed and found to cause a click on the bony ridge between the articular and non-articular surfaces of the femur. On the synovial surface of this scar was an irregular white line which was hard and gritty and without mucous cells. In view of these findings he operated on 103 knees through the horizontal incision used for many years by Platt. Operative technique is described as a two inch horizontal incision at the level of the head of the tibia from the patellar ligament to the collateral ligament, through skin and capsule. The synovia is opened along the superior border of the meniscus which is then removed in the usual manner. End result of 103 soldiers showed 76% perfect or much improved, 16½% a little better or the same and 7½ percent worse. It was the author's impression that the immediate recovery was quicker and less eventful with the horizontal incision. Early arthritis, ulceration of the articular cartilage and ligamentous instability were recognized at operation in 23 cases with the same per cent of successful results. Total and sub-total removals analyzed separately showed no material difference in the results. (Ed. Note: No reference was made to the time elapsed between operation and evaluation).

12. Surgery, Arthrodesis - Charnley (23) reports 15 cases of arthrodesis of the knee joint by the use of a positive pressure method which he believes is superior to any other. Clinical union was obtained in from 12 days to 6 weeks after operation. Under force of compression a cellular response is stimulated in the osteoblasts. Although fixation is important he believes compression is the main factor. The technique of the method is described. The theoretical conception of how bone union occurs under compression is given with illustrations. The technique comprises the insertion of Steinmann pins transversely through the femur and tibia and connecting them with a longitudinal bolt on each side so that they can be approximated with wing nuts. The pins are arranged to lie on a Thomas splint for immobilization.

13. Surgery, Arthroplasty - Samson (24) reported late results in 43 arthroplasties of the knee joint followed for more than five years. The cases include gonococcal arthritis, 10; traumatic arthritis, 2; osteomyelitis, 1; and tuberculosis, 1. The indication for arthroplasty was ankylosis of both knees or of the hip and knee joints on the same side.

Only active resistive exercises were used and when necessary manipulation under anesthesia. Pain was not complained of and only one unstable knee due to absorption of the medial femoral condyle was reported. All had full active extension with flexion from 20 degrees to 90 degrees or more. Re-ankylosis occurred in 12 cases.

Mayer (25) reports a case of arthroplasty of the knee done on a patient with rheumatoid arthritis in whom the opposite knee had previously been fused. A satisfactory arthroplasty was produced without the use of metal or of soft tissue flaps interposed between the bone ends. It was thought that the good result was due, in part at least, to continuous traction for three months post-operatively, combined with daily assisted active motion started 10 days post-operatively.

14. Surgery, Patellectomy - Gray (26) discusses the incidence, anatomy, radiological examination, and clinical features of chondromalacia of the patella. He recommends excision of the patella, as he feels that it is impossible to restore the smoothness of the articular cartilage. He reports seven cases who had excellent results following patellectomy.

Coleman (27) reviews the merits of excision of the patella. In his series of 32 cases the results were excellent in 23, good in 6, fair in 2, and poor in 1. He considers that early motion, with intensive quadriceps resistance exercises are important. A frequent complaint was aching in the knee, after long sitting, which was relieved by straightening the joint.

McFarland (28) advocated excision of the patella as the operation of choice for recurrent dislocation. The immediate result is excellent and late osteoarthritis is avoided. A typical case is presented with color photographs showing the pathological changes in the cartilage of the patella and the femoral condyle at operation.

15. Surgery, Synovectomy - Pardee (29) reviews the literature relating to synovectomy of the knee joint and lists the following pathological conditions as benefited by synovectomy:

a. Chronic infections; b. Traumatic arthritis; c. Hypertrophic arthritis; d. Osteochondromatosis; e. Benign tumors; f. Intermittent hydrarthrosis; g. Villous arthritis; h. Pigmented villonodular synovitis.

He considers tuberculous synovitis a contraindication for synovectomy. A general statement expressing the opinion of the majority of the authors as to the indications for synovectomy could not be made. Pain is probably the paramount indication. The author presents a series of 40 patients operated upon. Eight had bilateral synovectomy and all requested the second operation because of the relief obtained from the first synovectomy. The end result after one, two, and five years are shown in a chart. The immediate excellent result is often misleading. The end result in terms of relief of pain and increase of function are universally good in cases of traumatic arthritis, chondromatosis and benign tumors with the poorest results in polyarticular rheumatoid or hypertrophic arthritis.

Paparella-Treccia (30) agrees with Wittmoser that the meniscus of the knee contains two histological elements, chondroid and tendinous, in the

relation of two to one. After the embryological development has been concluded there is no blood supply to the chondroid tissue. The tendinous portion receives some blood supply from the capsular arteries. The author studied photomicrographs of the menisci in 8 cases of poliomyelitis. He found that:

(1) the menisci had lost the differentiation between tendinous and chondroid portions.

(2) there was an increase in blood supply to the structures adjoining the menisci.

(3) there was vascular invasion along the convex margin of the menisci and also at the concavity.

(4) there was appreciable histological evidence of blood vessel proliferation with the greatest vascular invasion in the cases with the most severe nerve involvement.

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SECTION 15

CONDITIONS INVOLVING THE FOOT AND ANKLE

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Anatomy

Lapidus (1) contends that man is the only primate that has fully adopted the upright plantigrade stride and that only man has a longitudinal arch. He believes that the foot is a rigid frame created to provide strength in response to the new functional requirements of the upright plantigrade stride. The integrity of the arch in standing is maintained mainly by passive support of the ligaments, the muscles playing a secondary part. The theoretical shock absorbing function of the arch compared with the semi-elliptical spring of a carriage is not acceptable since the plantar fascia and ligaments are not elastic.

Kaplan (2) points out that retraction on the common peroneal nerve in operations near the upper end of the fibula often results in weakness or paralysis of the extensor longus hallucis muscle. The muscular branches of the deep peroneal nerve (anterior tibial) vary in size and length. The nerve to the extensor longus hallucis is frequently found in cadavers to be the longest and thinnest of these branches. Forceful retraction upward and posteriorly on the deep peroneal nerve in these cadavers produced a tear of the nerve to the extensor longus hallucis muscle. If the retraction was made forward and upward, nerve damage did not occur. Therefore, in operative procedures near the head of the fibula, it is advisable to place the knee in slight flexion and gently retract the nerve over the fibular head upward and forward.

Mechanical Abnormalities

Harris and Beath (3) report their observations in the study of the feet of 3600 recruits in the Canadian Army. They divide flat foot into 3 types: a. hypermobile flat foot with short tendo Achillis, b. peroneal spastic flat foot, and c. simple depression of the longitudinal arch. Hypermobile flat foot with short tendo Achillis is based on a congenital anomaly of the structure of the talus and os calcis, so the deformity appears early in life. There is a strong hereditary tendency. The typical flatness is present only on weight bearing and normal shape is resumed when weight bearing is removed. It can usually be corrected by voluntary effort on the part of the patient. The range of dorsiflexion of the ankle is greatly limited due to the short tendo Achillis. There is also an undue laxity, instability and hypermobility at the subtalar and midtarsal joints. The forepart of the foot is swung out and there is external rotation in relation to the leg. The calcaneus is in valgus and the head of the talus is thrust forward and downward. The incidence of the severe type of hypermobile flat foot was one in every 145 men examined.

In the 3619 soldiers examined, there were 25 cases of severe and 192 cases of mild hypermobile flat foot. Examination of the foot bones of 200 cadavers in the Dept. of Anatomy at the University of Toronto revealed marked variation in the mechanical sufficiency of the talo-calcaneal articulation which would appear to be the basis for the instability of this joint. The authors made x-ray studies of the feet of the 3619 soldiers and found a close parallel between weak support of the talus as evidenced on the films and the presence of hypermobile flat foot with short tendo Achillis. The basic factor is bony instability but the support of ligaments and muscles is a modifying contribution. In the strong foot little load is thrown on the muscles. In the average foot the complementary contributions from the skeleton and muscles provide satisfactory stability. In the weak foot, the load thrown upon the muscles is unduly great. Treatment consists of shoe modifications to assist the weakened skeletal support and exercises to improve muscle power. In the severe cases which do not benefit by conservative means, the authors recommend fusion of the talo-navicular and talo-calcaneal joints with implantation of cancellous bone grafts. Late adolescence or early adult life is the optimum time for such a procedure. They estimate that 10% of such cases are suitable for operative treatment.

Harris and Beath (4) find it difficult to believe that the condition known as peroneal spastic flat foot develops from a flexible flat foot by reason of the stresses which fall upon the tarsal joints. Flexible flat foot is common in childhood and not accompanied by spasm. Spastic flat foot is rare, usually dates back to childhood and there is the history that the foot was always stiff. Furthermore, procaine block, nerve section and even tendon section are often followed by a persistence of the deformity and rigidity. Of 3600 Canadian males examined for enlistment, 74 had peroneal spastic flat foot (2%). In nearly all cases the lateral films showed lipping of the superior margin of the head of the talus.

At operation two years previously on a case of peroneal spastic flat foot the authors noted a bridge of bone springing from the medial surface of the talus and continuing to the medial surface of the calcaneus. Since then they have noted this abnormality in 12 of 17 additional cases. Of the remaining 5, three had bony bars between the calcaneus and navicular and two had tarsal rheumatoid arthritis. X-ray visualization of both the calcaneo-navicular bar and the talo-calcaneal bridge is accomplished by a postero-anterior projection thru the heel at the downward angle of 45 degrees, the leg shadows being separated by flexing the knees. The authors believe that most cases of so-called peroneal spastic flat foot are due to these two congenital anomalies, that the apparent spasm is really only an adaptive peroneal shortening and that these cases are rigid rather than spastic. There is a smaller group of patients with rheumatic conditions of the feet in which true peroneal spasm is a secondary feature. The authors recommend subtalar and talonavicular arthrodesis in the rigid cases when disability is severe. In cases with severe deformity the peroneal tendons may be lengthened. Operation is not done until adolescence in any case. In childhood repeated manipulation and the use of Whitman plates are the methods of choice.

Apley (5) reports a case of a five year old boy with weakness of the legs and a tendency for the feet to give way into a position of marked valgus with collapse of the long arches when he attempts to stand. There

is the history of a dermoid cyst having been removed shortly after birth from the upper dorsal region followed by moderate hydrocephalus and retarded physical and mental development. There was a bilateral extensor Babinski reflex. The author attributes the inability to stand in spite of the presence of leg muscles to the underlying neurologic condition with failure to acquire a normal postural reflex. Since the muscles are unable to balance the body on the feet, the longitudinal arch collapses. The author postulates that lack of myelinization of the pyramidal tract may inhibit the development of the postural reflex.

Baker (6) states that an examination of the feet of 3000 young women during World War II revealed that in 47% there was the need of some treatment for a foot disorder and that, of these, 25% actually required treatment before they could be employed in the Auxiliary Territorial Service. The condition which caused most pain and loss of working hours was the postural valgus or unbalanced foot. A very small percentage had structural changes. Since the war the author has been working with school children and prescribing postural foot exercises designed to mobilize all essential joints, to strengthen muscles and to induce relaxation.

Fitzgerald (7) points out that a high arch may more frequently give rise to trouble than a low one. Support of the long arches of the feet is dependent upon the bony structure and the ligamentous attachments, with considerable aid from the muscular structures. These cases are divided into four groups: (1) postural flat foot, usually in adolescence and due to muscular weakness, (2) equinus flat foot secondary to short tendo Achillis, (3) flat foot due to metatarsus varus, and (4) rigid flat foot. The standard methods of treatment are briefly described.

Tucker (8) reviews briefly the anatomy of the foot and the etiology and treatment of postural or static flat foot, the flat foot of early childhood, spastic flat foot and Morton's metatarsalgia.

Nissen (9) states that the neuralgic pain felt in the sole of the foot in the region of the 3rd and 4th toes, with onset on standing or walking and relief by removal of the shoe, was described by T. G. Morton in 1867. Betts in 1940 described a fibrous swelling of the plantar digital nerve as the pathologic finding, with complete relief by resection of the nerve. The author studied 27 cases of plantar neuralgia. Only one patient had definite swelling in the digital cleft and diminished sensation was only an occasional finding. The condition was bilateral in 8 cases. Thirty-five operations were performed by longitudinal incisions between the common flexor sheaths. Usually the nerve is sought where it crosses the transverse ligament. The whole nerve and vascular bundle are excised. The author has had no difficulty with the scar from weight bearing and pain disappears within a few days. Histologic examination revealed degeneration of the digital artery with fibrosis of the digital nerve. The nerve changes are thought to be ischemic in origin.

Winkler, Feltner and Kimmelstiel (10) review a series of 20 patients with pain and tingling in the region of the 3rd and 4th toes and tenderness and a sensation of a nodule in the web between these toes. Relief was

obtained by operation. A dorsal incision was used and the thickened enlargement of the plantar digital nerve was resected. There were no trophic complications. Pathological changes in the nerves consisted of massive thickening together with fibrosis and myelinization of the perineurium. The authors attribute these changes to a degenerative process subsequent to trauma.

Jones (11) states that hallux valgus may reveal itself in early adolescence and occurs in these cases almost invariably in females. Abduction of the great toe and permanent bunion may occur as early as 12 years of age. It is due to congenital or developmental adduction of the first metatarsal bone possibly on an atavistic basis. Secondary changes and deformity may be due to shoe pressure. Lesser deformities can be improved by stretching, exercises and night splinting. In more severe cases simple excision of the exostosis without interference with the epiphysis at the base of the phalanx or resection of the head of the metatarsal may be adequate. Usually however, a wedge shaped osteotomy thru the proximal portion of the shaft of the metatarsal is indicated. Only a portion of the wedge is removed and the remainder is fixed into the proximal medullary canal for stabilization. Six weeks immobilization in a leg and foot plaster is required postoperatively. Good results are usually obtained but the operation is only done when there is persistent pain from shoe pressure. After operation the subluxation of the phalanx is automatically relieved. The procedure is entirely extra-articular.

In the etiology of painful heels, Wood (12) considers periostitis, exostoses, fractures, epiphysitis, retrocalcaneal or plantar calcaneal bursitis, the "neuralgic heel", strain of the plantar fascia, and various skin lesions. The treatment of each condition is briefly discussed.

Pridie (13) reports the development of a mass-produced molded rubber heel for the correction of unbalanced and pronated feet. The rubber heel is elongated along the medial border, has a flange to support the region of the longitudinal arch and has the added effect of a 1/8" inside wedge. The device has the advantage of flexibility and ease of application with avoidance of rigid fixation of the foot. The ordinary heel is removed by the retailer who stocks the molded curator heel and the supportive, properly fitted rubber heel is applied in its place.

Traumatic Disturbances

Gibson and MacKinnon (14) present four cases of subtalar dislocation of the foot with minor fractures. In spite of the admittedly precarious blood supply to the talus there was no aseptic necrosis in their cases nor has it been reported in the cases described in the literature on this subject. All authors emphasize the relative ease of closed reduction by plantar flexion and abduction. Secondary operative procedures for traumatic arthritis are not usually required.

Bell (15) reports a case of medial and posterior dislocation of the foot thru the subastragalar joint without evidence of fracture. The injury was due to severe adduction and plantar flexion of the foot in a

baseball accident. Reduction was accomplished by manipulation under anesthesia with further plantar flexion of the foot and forceful abduction. The treatment consisted of immobilization in a non-padded plaster for six weeks with weight bearing at the end of 10 days. Early return of motion was noted on removal of the plaster. The late result is unknown.

Newcomb and Brav (16) report the rare instance of a complete dislocation of the talus from its normal articulations. There was apparently a 90 degree rotation of the bone thru both vertical and horizontal axes. The position of the bone was transverse to the horizontal axis of the foot and its posterior portion was lateral and anterior to the fibula. There was no fracture. Reduction was accomplished by Kirschner wire traction thru the calcaneus with counter-traction on a Steinmann pin thru the tibia. Pressure in a postero-medial direction over the lateral prominence of the talus accomplished the reduction. The wire and pin were removed after roentgenograms revealed restoration of normal anatomy. Four weeks immobilization was carried out. Roentgenograms at the end of six months revealed no evidence of aseptic necrosis in spite of the marked disruption of capsular attachments and obvious circulatory embarrassment which were present at the time of injury. The major nutrient supply to the talus is thru the dense superior talonavicular ligament. Some remaining strands of this ligament may have been the basis for revascularization of the totally displaced talus.

Goldstein (17) points out that in severe sprains of the ankle, injury to the lateral ligaments must be suspected. Negative routine x-ray examination does not rule out serious injury. In rupture of the ligaments there is usually the history of a snap at the time of injury and an egg shaped swelling occurs below the lateral malleolus. Tenderness over the distal tibio-fibular joint is a constant finding. Forty-one such ankles were subjected to inversion stress under anesthesia and 29 of these showed 30 degrees or more tilt of the talus. Seven showed less than 30 degrees tilt and 5 showed no tilt. The uninjured ankle was always similarly tested. Occasionally as much as 10 degrees tilt has been noted in normal ankles. The author treats the cases with significant tilt by short leg plasters in the neutral position for a period of eight weeks. He concludes that correct diagnosis and adequate treatment will prevent the symptoms of an unstable ankle. Of 101 acute ankle sprains seen in an Army General Hospital, 28% were found to have complete rupture of the lateral ligament. The importance of examination in inversion and adequate immobilization to prevent permanent disability is stressed.

Kestler (18) emphasizes that early and accurate diagnosis of minimal as well as extensive trauma to the ligamentous structures of the ankle joint will insure the possibility of a good end result. He recommends that every inversion injury of the ankle be subjected to special x-ray examination accomplished under 2% procaine anesthesia produced by injection into the sinus tarsi, $1\frac{1}{2}$ " anterior to the tip of the lateral malleolus. An A-P view is then taken with the forefoot held in extreme inversion. In a series of 15 normal ankles so anesthetized and examined, no degree of tilt of the talus was noted. The authors had eleven traumatic cases which revealed a tilt of the talus on this examination. Five were noted shortly

after injury and were treated by plaster fixation for 8-12 weeks. Of the chronic cases, three were mild enough to be improved by similar conservative treatment, but three required operative repair.

At the Annual Meeting of the Canadian Orthopaedic Association, Pennal (19) presented an anatomic and clinical study of injury to the anterior and middle fasciculi of the external lateral ligament of the ankle with tilting of the talus on roentgenographic examination of the inverted foot. The importance of adequate treatment in the acute cases to prevent chronic weakness and recurrent dislocation was stressed. In the refractive types treatment by tenodesis of the peroneus brevis muscle resulted in stable painless ankles with full range of joint motion.

Leonard (20) studied 51 inversion injuries of the ankle. Twenty-three were shown to be spontaneously induced subluxations by roentgen examinations under local or general anesthesia. Experimentally, a study of seven preserved ankles in which all soft parts except the collateral ligaments had been removed, suggested that the ligament most commonly injured was the anterior talo-fibular and this is the usual area of the local tenderness clinically. When the foot is in equinus, after cutting the anterior talo-fibular ligaments, there is less stability than when the foot is at a right angle. Inversion films should therefore be made in equinus.

Pearson, Adams and Denny-Brown (21) report the case of a twenty four year old male who complained of severe pain in both legs shortly after engaging in broad jumping on a cement sidewalk. There was the development in twenty-four hours of a moderate fever, with swelling and tenderness of the pre-tibial muscles and bilateral paralysis of the anterior tibial, extensor digitorum and extensor longus hallucis muscles. Albuminuria developed within a few days. The pain and tenderness gradually subsided but paralysis continued. Muscle biopsy on the 17th day revealed hemorrhage, extensive muscle necrosis and proliferation of fibrous tissue. The systemic reaction gradually subsided but five months later the paralysis was still present. The authors believe that absence of reflex changes or sensory loss and the lack of electrical excitability of the involved muscles excluded a peripheral nerve lesion. There was no evidence either clinical or pathological of an injury to the anterior tibial artery. It is concluded that violent muscular exertion caused partial rupture of the muscle fibers and the attendant hemorrhage and swelling produced ischemia and necrosis.

Bonnin (22) discusses the common bone injuries to the foot and ankle and divides the ankle fractures into traction and compression injuries. The latter may occur alone but are more commonly combined with external rotation, abduction or adduction forces. The treatment of each variety is discussed. In the case of fractures of the os calcis, the author considers only two types - the first, in which the subtalar joint is damaged and the second, in which it is not. He states that this is the determining factor in the prognosis and not the change in the so-called salient angle. Maneuvers to restore the shape of the bone require considerable force and a long period of immobilization which adversely affect the end result. It has been shown that it is more profitable to exercise the foot and ankle from the beginning. Elevation is used until swelling subsides. Generally

the foot is too painful for weight bearing until 6-8 weeks but massage and exercises are utilized almost at once. By this regime, patients get on their feet more quickly, the incidence of post-fracture pain is diminished and, while cases of subastragalar arthritis demanding eventual arthrodesis will not be completely avoided, fewer will be encountered.

Starr (23) discusses tibio-fibular diastasis and its treatment by screw fixation with or without denuding the tibio-fibular joint. Chronic sprain of the lateral ankle ligaments may be associated with osteochondritis dissecans of the astragalus and often requires operative repair and reinforcement by a transplant of peroneus tendon. Ankle, metatarsal, os calcis and astragalus fractures are briefly discussed.

Developmental Abnormalities

Zadek and Gold (24) found eight children with accessory tarsal scaphoids, six being bilateral. These 16 feet were x-rayed at intervals to determine the fate of this accessory element located medially and posteriorly to the tubercle of the tarsal scaphoid bone. Definite fusion occurred in 5 instances, partial in 3 and failure of fusion in 6. The authors made sections of excised accessory scaphoid bones and their continuous scaphoid surfaces. In no case was there a true joint surface present. Ordinarily there was a layer of soft tissue consisting of hyaline cartilage, fibro-cartilage or a mixture of the two. No synovial-lined joint capsule was encountered. There were varying degrees of ossification of the cartilaginous plate. The authors noted evidence of trauma in the specimens in the form of hemorrhages, organizing fibrous tissue and callus-like reparative tissue. It is possible that these accessory scaphoids may be painful due to stress from the posterior tibial tendon as a result of mechanical foot weakness. Other traumata must also be considered in the etiology of the discomfort.

Hughes (25) observed a series of x-rays of the heels of 23 children complaining of painful heels compared with x-rays of painless heels thru the age period between 6 and 14 years. Altho most writers have attributed these painful heels to osteochondrosis of the epiphysis of the os calcis and have compared the condition with Osgood-Schlatter's disease, the author could find no roentgenologic appearance in the painful group to distinguish it from the asymptomatic varieties. Both groups showed cases of irregularity, flattening, fluffiness and fragmentation of the epiphysis. The epiphyseal line was often clouded and in some areas obliterated. It is concluded that since there is no histologic evidence of a diseased epiphysis in these painful heels and since the roentgenologic appearance is similar to that seen in painless heels, there is no proof that osteochondrosis or epiphysitis is the underlying cause of the patients' complaints.

Skin Conditions

Russell (26) decries the use of radiation therapy in the treatment of plantar warts and advises repeated formalin soaks followed by removal with scissors, or a combination of curettage and electric cauterization. Hanby (27) believes that the chiropodist can take care of most cases of plantar warts in 3 or 4 visits and there is no scarring or temporary disability. A few resistant cases may come to the surgeon.

Kurtin and Yontef (28) feel that the treatment of plantar warts consists in trimming until a cavity is produced. The foot is then held horizontal and a drop of 25% suspension of resin of podophyllum in liquid petrolatum is placed into the cavity. The surrounding skin is painted for a distance of $\frac{1}{2}$ " with collodion. A 2" strip of well flamed adhesive tape is then placed directly over the lesion. The patient resumes activity and the adhesive may be reinforced but it is not replaced for eight days. The base of the wart then appears as a grayish substance which can be scooped out. The podophyllum is then re-applied and the treatment repeated. After the third or fourth treatment a clean painless cavity is seen. Tissue reaction is minimal. The cavity heals rapidly and in a few days healthy tissue reaches the surface. The authors postulate that the success of their treatment depends on the creation of a constant macerated state of the tissue by the adhesive. This produces the medium which is present in genital warts where podophyllum treatment has been found so efficacious. The results of this technique in a small series of plantar warts has been very satisfactory.

Watkins (29) reviews 150 cases of plantar warts in children. The largest percentage (66%) occurred between the ages of 11 and 15 with only 7% between 5 and 7 years. The majority had only one wart, but 23 cases had multiple warts. 80% occurred on the plantar metatarsal area and 20% on the heels. The treatment was by means of excision of callus and the application of chlorosal (60% salicylic acid and 5% chloral hydrate) covered with adhesive. Treatments were repeated in 7 to 14 days. An average of three treatments was required. There were no recurrences.

McLaughlin (30) states that radiotherapy of plantar warts often produces burns which cause severe disability entirely disproportionate to such a simple condition. The author recommends simple treatment under local anesthesia by excision of callus and thorough reaming out of the wart with a curette. The base is then touched with a diathermy needle or an electric cautery to prevent recurrence. This produces a saucerization of the area. A plug of gauze is inserted for 48 hours but the patient starts weight bearing immediately. Healing is usually complete in 7-10 days.

Tobias (31) classifies plantar warts as (1) the solitary common variety, (2) multiple (65% of cases), (3) infective, (4) mother-daughter type, and (5) mosaic warts which occur in map-like arrangement and are not painful. Warts usually appear over pressure points. The author has never seen a case in a Negro. The incidence is greater in women. Epidemics of warts among school children have occurred, indicating some infectious element. The exciting cause is thought to be an epitheliotropic virus. The author recommends radiation treatment with an average dose of 2100 r. in 3 fractionated doses. No roentgen sequelae occurred in these cases. There were only 9.6% failures by this method. It is stated that radiation necrosis may occur from overdosage, frequent small doses, careless records or failure to shield the wart to the very edge of the lesion. No patient should be treated who has received previous x-ray therapy until the exact previous dosage is known.

Shaw (32) states that in some cases of plantar warts treated by radiation, chronic intractable ulceration of the sole resulted in disability

out of all proportion to the importance of the original lesion. Recurrence follows simple excision of the ulcers and deep fibrosis leads to an unstable tender scar which prevents normal walking. Free skin grafts are unlikely to provide permanent cover. The author reports two cases treated by direct pedicle flaps from the opposite leg. The ulcer was excised and the flap raised and partially attached. Three to four weeks later the flap was separated and completely attached to the site of ulceration. Healing occurred rapidly in both cases and walking was comfortably accomplished about two months after the initial procedure.

Operative Procedures

To overcome the objection of a formidable operative procedure and the cosmetic result of a thick ugly ankle which often attends arthrodesis by complete elimination of articular surfaces, Gallie (33) has devised a simpler procedure which is equally effective. Two vertical incisions in front of the malleoli expose the ankle joint. Deep mortises $1\frac{1}{2}$ " long, $\frac{1}{4}$ " wide and 1" deep are cut across the joint surface on either side. Thru a third incision in front of the leg, a cortical graft 3" long and 1" wide is cut from the tibia. This is divided in two, and each half is hammered solidly into the mortises in front of the ankle. When this has been accomplished no motion is present and the skin can be closed without fear of displacement. The proper degree of equinus must be produced before the mortises are cut. The author has used the method in 25 cases. Four months of plaster immobilization is required. The procedure produces no shortening and no ankle thickening, it can be done in a short period of time and the grafts are placed so that there is minimal strain when weight bearing is begun.

Adams (34) describes his technique of ankle arthrodesis which consists of a transfibular approach and the use of the lower 4" of the fibula as an onlay graft after removal of its medial cortex. The cartilage is removed from the talus and the tibia thru the lateral incision and cancellous chips are used for dead spaces. The fibula is then fastened across the joint laterally by three screws. Weight bearing is encouraged in a few weeks but plaster fixation is used for a minimum of 12 weeks. A series of 30 cases is reported with primary success in 28, but two patients required secondary procedures.

In cases of 5th hammer toes which do not respond to conservative treatment by metatarsal pads and sole wedges, Michele and Kreuger (35) recommend a subperiosteal resection of the entire proximal phalanx. The capsular attachments are separated carefully from the proximal and distal ends of the phalanx and these structures are sutured following removal of the bone. The patient is ambulatory in one week and results have been satisfactory from the functional and cosmetic viewpoints in 61 cases.

Sallick and Blum (36) report that in severe crush fractures of the heel and, in some cases, in spite of minimal anatomical disturbance following careful reduction, patients have been left with disablingly painful feet. Conversely, some severely crushed bones give relatively painless feet. Correction of skeletal deformity is not the only objective.

Relief of pain might be an important physiologic approach to the problem regardless of the bone changes, so denervation of the heel occurred to the authors as a possible solution. This has been used extensively in the treatment of pain in peripheral vascular disease. The tibial and sural nerves are responsible for sensation of the heel. These nerves are chiefly sensory at the ankle but in the case of the tibial nerve there is a motor element to some of the small plantar muscles. Division of the nerve results in no significant loss of function but, since sensory loss to the sole of the foot would be produced, the medial calcaneal branch of this nerve is the portion which is attacked. The approach is thru two short vertical incisions posteriorly, just above the ankle. The authors report seven cases all of whom had persistent pain for 1 year following heel fractures before denervation was done. They were followed four months to five years after nerve section. Four patients have returned to work but in three the disability has persisted. Cases must be carefully selected, must have had adequate conservative treatment and display a desire to get well. There was little choice between resection or simple division and resuture. No trophic sequelae occurred in this group of patients.

At the meeting of the Canadian Orthopedic Association, Frenette (37) reviewed a series of 756 cases of infantile paralysis treated by tendon transfer, astragalectomy, arthrodesis and bone block. The results of tendon transfer alone were good in 67%. When used in conjunction with stabilization procedures there were good results in 86%. Astragalectomy resulted in painless stable mobile feet in 76%. Arthrodeses of various types were satisfactory in percentages ranging between 80% in the case of triple arthrodesis with or without bone block and 92% in the cases of panarthrodesis for stabilization of the foot in equinus, either to compensate for shortening or to permit locking of a flail knee in hyperextension.

Schnute (38) and his associates have performed 26 foot stabilizations of the Lambrinudi type with uniformly good results. The preoperative planning of the wedge to be removed, the location of the notch in the inferior surface of the scaphoid and the maintenance of the normal astragalo-calcaneal relationship to avoid a varus foot are technical details to be carefully considered.

Ficai (39) states that no case of dislocation of the foot without fracture of the malleoli has been reported and many authors have denied the existence of such a lesion on theoretical reasons. He describes the case of a 25 year old soldier who fell from a truck and sustained a simple posterior dislocation of the ankle without fracture. Upon examination the patient was unable to move his foot. X-rays revealed a small chip from the internal malleolus. No other bone pathology was found. The dislocation was reduced under general anesthesia and maintained in plaster for 10 days. The patient returned to normal function 20 days after removal of the plaster. The author presumes that the patient had pre-existing relaxation of the ligaments and feels that otherwise the injury would have included a fractured malleolus or at least a tibio-fibular separation.

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SECTION 16

CONDITIONS INVOLVING THE SHOULDER AND NECK

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Anatomy

Nauta and Landsmeer (1) review the anatomy of the periarticular tissues of the shoulder joint. Their study includes the observations of other anatomists, in particular Rouvier's and Frohse Frankel's text books, and the special papers of Henke, Pfuhl and Kahlmeter as well as their own personal observations. A description of the subacromial bursa is especially well presented. The authors agree with Pfuhl that there is sufficient reason to regard this bursa as a true joint, although an exceptional one functionally and morphologically. The belief is founded on the following facts; (1) the argument of Pfuhl that the portion of musculo-tendinous cuff formed by the supraspinatus tendon and the coracohumeral ligament can be regarded as an intra-articular disc, (2) it is the only bursa known to be able to reduce friction between two skeletal elements (the greater tuberosity of the humerus and the acromion), and (3), it has a mechanism, through its attachment to the subdeltoid fascia, which keeps it extended during movement in a manner similar to the mechanism about two joints which prevents intra-articular incarceration of capsular folds. Functionally, therefore, the bursa acts to reduce the conflict arising between the shoulder joint, which is an exceptionally mobile structure, and the rigid tissues surrounding it. Morphologically, it differs from true joints in that it is largely a synovial sac with only a minor portion of its wall composed of cartilage.

In a comprehensive, well illustrated report on the nerve supply of the shoulder joint, Gardner (2) adds to our present knowledge of the innervation of this region. Modern texts of anatomy describe in varying detail its innervation by the subscapular, axillary, suprascapular and anterior thoracic nerves. His study is based on the dissection of 7 adult shoulder joints and serial sections of 4 fetal shoulders. Four additional adult shoulders were partially dissected to confirm points brought out in the fetal shoulder studies. In addition to confirming the major features of existing descriptions, Gardner was able to demonstrate nerve branches not previously described. In two fetal specimens small twigs arose from the radial nerve, ascended in the adventitia of the brachial artery to the origin of the anterior circumflex humeral artery where they appeared to anastomose with the bicipital branch of the axillary nerve. In the same specimens another twig of the radial nerve, ascending the long head of the triceps brachii, was traced just up to the capsule of the joint where it disappeared. An articular branch of the posterior cord of the brachial plexus was initially discovered in the fetal specimens and later confirmed in dissections. It supplies fibers to the anterior region of the capsule and synovia, also supplied by the branches of the suprascapular and anterior thoracic nerves. Fetal sections also focused attention to articular branches of the lateral anterior thoracic nerve. These branches accompany

a branch of the thoraco-acromial artery and after crossing the coracoid process reach the acromioclavicular joint and send a twig to the antero-superior region of the shoulder joint capsule. Sympathetic fibers were traced in two fetal specimens from their origin in the stellate ganglion in one specimen, and the sympathetic trunk just superior to this ganglion in the other, to the shoulder joint. Fibers of similar origin found in the other two specimens could not be followed beyond their entrance into the adventitia of the axillary artery. In addition to this previously undescribed innervation of the shoulder joint the author traces in detail the courses of the articular branches of the axillary, anteriorthoracic and suprascapular nerves.

Krahl (3) believes that the spiral course of the bicipital groove is visible evidence that torsion has occurred in the proximal diaphyseo-epiphyseal joint. In the adult humerus the bicipital groove describes a gentle spiral course from lateral to medial as it descends, and the angle through which it turns bears a fixed relationship to the torsion angle. This angle slowly increases with age up to the 20th year, and the degree of torsion is in direct proportion to the force of muscles which rotate the humerus.

Recurrent Dislocation of the Shoulder

Palmer and Widen (4) believe that the essential lesion contributing to subluxation, a term they feel more descriptive than dislocation, is the deformity of the humeral head. In a study, based on 60 operations, this lesion, described as a typical compression fracture in the posterior part of the head was constant, as demonstrated by radiograph, arthrograph, and at operation. The labrum showed varying degrees of injury in 56 cases, but in 4 instances no abnormality of this structure could be demonstrated. They use a bone block in the repair of all their cases, a technique first described by Hybbinette and Eden, and briefly present the operative steps in this procedure. In a follow-up study varying from 1-1/2 to 12 years, there was recurrence of dislocation in 4 of their cases (6.7 percent). Recurrence in each instance followed severe trauma.

Hark (5) found lesions of the glenoid labrum and capsule in each of 40 shoulders operated for recurrent dislocations. Seventy five percent of his cases were former soldiers, and the glenoid disruption in this group was more extensive than in the civilian group. In those cases where there is erosion or separation of the glenoid lip, he uses a bone peg graft obtained from the coracoid process to deepen the anterior glenoid rim.

In a series of 17 consecutive cases of recurrent dislocation of the shoulder joint Eyre-Brook (6) found detachment of the glenoid labrum plus a groove on the posterior surface of the head of the humerus in 8 cases, detachment of glenoid labrum and capsule alone in 5 cases, groove on the posterior surface of the humeral head alone in 3 cases, and one case with detachment of the subscapularis muscle from its insertion.

Adams (7) reviews 180 cases of recurrent dislocation of the shoulder occurring in members of the Royal Air Force. One hundred and fifty nine

operations were performed to correct this disability. At surgery, examination of the glenoid labrum disclosed detachment of the labrum as described by Bankart and others in 87 percent of 79 cases examined. When detached, some degree of stripping of the anterior capsule from the scapular neck was invariably present. Adequate radiographic examination of the humeral head in 68 cases showed well defined bone defects to be present in 56 (82 percent). In all of the cases without labrum detachment (13 percent), a defect in the humeral head was present. It is his belief, on the basis of these findings, that the major causative factor permitting redislocation is the glenoid labrum detachment and capsular stripping from the anterior scapular neck. But, dislocation may result without the presence of this pathology, and is due to the defect in the head of the humerus. Five mechanisms producing the original dislocation are discussed; (1) Fall on the abducted arm. (2) Direct blow from behind, acting on the head of the humerus. (3) Hyperextension of the abducted arm. (4) Excessive external rotation in abduction. (5) Inferior dislocation following hyperabduction of arm. The Nicola procedure was done on 59 cases with 36 percent recurrence, the Bankart on 18 cases with one recurrence, and the Putti-Platt on 37 cases with two recurrences. Although, following the Nicola procedure, less limitation of external rotation of the shoulder results, the author feels that this operation is seldom, if ever, indicated, and that on the basis of his results the Bankart or Putti-Platt operations consistently yield satisfactory results in over 95 percent of cases treated.

(Ed. note: It would seem from these reports that the difference in pathology encountered in the shoulder joint subject to recurrent dislocation is one of degree. Detachment of the labrum, stripping of the anterior capsular attachment to the scapula, and defects in the posterior humeral head may be present singly or in combination, depending, perhaps, on the forces and direction of initial injury, the frequency of redislocation, and the duration of the disability. In the American Air Forces, during World War II, there were about 20 percent failures following the Nicola repair. As these cases were not treated by a single surgical team, but by many individuals of varying surgical abilities, a portion of these failures may conceivably be the result of faults in reparative technique. No statistics are available as to the percentage of failures following Bankart, Magnuson or Roberts repairs).

The Bankart approach and the Bankart repair of the labrum, in all instances where it was found detached, (70 percent), was used by Watson-Jones (8) in 51 cases of recurrent dislocations of the shoulder joint. In addition, he routinely overlapped and double-breasted the capsule and shortened the subscapularis muscle in a manner similar to that described by Platt. All of these cases were successful. In an additional patient in which the approach was made over the superior aspect of the joint, only the Bankart repair was done. In this case operation failed within a 6-month period. He believes that the inference is obvious; that the success of the Bankart operation is due more to the operative exposure and subsequent resuture limiting external rotation, than to the repair of the labrial lesions.

Gallie and LeMesurier (9) introduce a method of fascial repair of the detached labrum. A 10-inch x 1-inch strip of fascia lata is threaded through the scapular neck at the glenoid rim anteriorly, passed through

the head of the humerus and is fixed to the coracoid fossa. Threading the fascia is done by first passing a long 1/4-inch drill point with eyelet from front to back through the scapular neck until the drill point protrudes from the skin posteriorly. This puncture wound is then enlarged slightly with a scalpel down to bone, the fascia knotted securely at one end, and the other end fixed to the drill point eyelet with heavy silk, and drawn anteriorly through the scapula tunnel until the knot impinges on the posterior scapular neck. This fascial buttress is entirely extra-capsular and has the double function of fixing the detached capsule to the glenoid rim and reinforcing it across the anterior joint surface. In a series of 175 operations performed since 1926 they report 7 recurrences. Two of these were the result of sufficient violence to dislocate a normal shoulder. The other failures were due to faulty surgical technique, in that the fascial strut was placed too low, permitting the humeral head to luxate anteriorly over it. All of the patients returned to their ordinary occupation, 80 of them being members of the armed forces who were returned to duty and later demobilized without pensionable disability.

Richardson (10) attempts to increase the functional articular area of the shoulder joint and thus discourage dislocation by elongating and shifting the coracoid process downwards and outwards. A brief description of this operative procedure is given. In a series of 16 operations he reports a successful result in 12 cases over a 1 to 2 year follow-up period.

Because it is based on sound physiological and mechanical principles and does not endanger vital structures in its surgical approach, Juers (11) prefers the Magnuson-Stack procedure for the correction of recurrent dislocation of the shoulder. He treated 34 cases by this method, and in those cases in which careful follow-up studies were available 15 to 18 months after surgery, the results were excellent.

Similarly, Giannestras (12) reports success in 91.6 percent of a series of 31 Magnuson-Stack subscapularis tendon transplantations. The author advocates more general use of this method as he feels that Magnuson's concept of lack of muscle balance resisting downward and forward displacement of the humeral head is sound. The operative procedure is described with a modification in a manner of attaching the tendon to the greater tuberosity.

The Putti-Platt operation for recurrent dislocation is described in detail in a beautifully illustrated report by Osmond-Clark (13). A history of the development of this operation is presented.

Warrick (14) reports three cases of acute posterior dislocation of the shoulder. Because this injury is unusual and the physical signs are often masked by soft tissue swelling, it is frequently overlooked during the patient's first visit to the physician. In two of his referred cases, the pathology remained unrecognized for 5 weeks. In the third patient an immediate diagnosis was obtained by vertical x-rays of the joint. He recommends, for more rapid diagnosis than is possible with stereoscopic films which require drying before reading, a vertical projection using a curved cassette in the axilla.

Axial roentgenograms of the shoulder joint are also recommended by Knutsson (15). He places the patient on his back with the arm abducted,

and directs the central rays horizontally toward the axilla, the film being placed in epaulet position on the shoulder.

Zadik (16) reports a case of recurrent posterior dislocation of the shoulder joint. In his patients the initial dislocation resulted from a direct blow to the anterior shoulder during a boxing match, and recurrences always resulted when the arm was directed forward.

Because of the difficulty of maintaining the head of the humerus in position after surgical correction of old dislocations, Neviaser (17) uses a long vitallium wood screw transfixing the head and glenoid. The screw is removed in three or four weeks and motion of the arm encouraged. He reports the successful use of this procedure in six cases, in none of which could harmful changes to the humeral head or glenoid fossa be demonstrated roentgenographically as a result of the screw.

Brockbank and Griffiths (18), describe the various manipulative methods of reducing dislocation of the shoulder joint as advocated by Ambroise Paré (1510-1590). Six manipulative methods are quoted verbatim from an English translation of his collected works published in 1678. The article is illustrated with reproductions of medieval woodcuts.

Acromio-Clavicular Joint

Moore (19) describes an original operative treatment which he has used in 24 cases of acromio-clavicular joint injury. He advocates its use in all but minor injuries to this joint. Through a Roberts approach the acromio-clavicular joint is exposed and its cartilaginous surface excised down to bone. The clavicle is fixed to the coracoid with double No. 26 stainless steel wire looped through drill holes in both structures after reduction of the acromio-clavicular joint. Accurate reduction of the acromio-clavicular joint is essential before this procedure is done. Postoperatively, a Velpeau type support is used for two weeks, a sling for two weeks and active exercises begun. The average convalescent period for these cases is about 40 days. This operative procedure was devised originally to relieve disabling arthritis of the acromio-clavicular joint, and was later found useful also in the treatment of acute separations and injuries of this structure. He believes that the development of a painful arthritic joint following dislocation is inevitable, and that this surgical procedure at the time of original injury will eliminate this disabling sequela. Microscopic section made on 20 acromio-clavicular joints in his series all showed the same basic findings in varying stages of progress. They consisted essentially of exuberant proliferation of young fibrous tissue from organized hemorrhage into the joint, fragmentation, and degeneration and fibrous overgrowth of cartilage. Grossly, loose bodies and cartilaginous flakes were found and frequently the entire articular surface of either the clavicle or acromion, but especially the clavicle, would be practically detached as the result of undermining by creeping granulomatous tissue. All of his patients have been followed for more than a year and although the author does not claim that these shoulders have been restored to normal, he feels that the results in his series seem to represent a definite improvement over previously reported results.

Bosworth (20) reports an end-result study of 8 cases of acromio-clavicular separation treated by the screw suspension method which he introduced in 1942. These cases were the earliest ones operated upon by the author. Nine additional cases, treated by other surgeons are reported, but not included in the summary of end-results. Of his cases, six were completely successful from an anatomic, economic and functional aspect. One case was equally successful, except that the screw was not inserted deeply enough and pulled out slightly, and in another case the screw broke and the operation was considered a failure. Several facts are disclosed by this study; (1) there has been no migration of screws, (2) the flanged screw, designed by the author, if placed through both cortices of the coracoid does not pull out, (3) maintenance of reduction is dependent upon firm healing of soft parts and not upon the screw, (4) reduction of the dislocation must be complete before the screw is inserted to eliminate excessive mechanical stress upon it. Early mobilization of the extremity, a short convalescent period and minimization of disability, are given as advantages of the screw suspension method.

A special plaster jacket incorporating an axillary crutch, is described by Morrison (21) as a method of treating acromio-clavicular dislocations. The method allows the patient free use of both arms and permits his immediate return to work if of a non-industrial nature. Good anatomic and functional results are reported in a series of six consecutive cases, treated by this method.

DEGENERATIVE LESIONS OF THE SHOULDER JOINT

The pathologic changes that occur in degenerative lesions of the tendons, capsule and cartilage of the shoulder joint are reviewed by Neufeld (22). In his opinion, these changes are primarily metabolic with heredity contributing an important role. Trauma, although of significance, cannot be the sole cause of degeneration, for the lesion is less frequently seen in men than in women and younger individuals subject to greatest trauma are unaffected, or only briefly so. Symptoms most commonly occur in the age group from 40 to 50 years, and begin as a slowly progressive ache in the shoulder, followed by a period of 8 to 24 hours of relative comfort before acute symptoms appear. During the acute pain if there is no evidence of calcification, the author's choice of treatment is the intermittent application of ice caps directly to the shoulder. These are applied for 20 minutes and removed for 20 minutes for a day or two when the acute symptoms usually subside. Penicillin and sulfa drugs are given if fever and leukocytosis is present. Movements which cause pain are strictly not prescribed, but are encouraged in planes where it is painless and are as rapidly increased in range as pain within this range disappears. Exercises are always of the active type. In those cases where calcification is demonstrated, surgical removal gives the most rapid long-term relief. In both types, with or without calcification, the immediate results following treatment are usually good. In the chronic type this function may persist for many months. These cases are apt to be overtreated in an attempt to hasten recovery, and excessive x-ray, diathermy and massage may actually prolong the disability. Temporary relief of discomfort can usually be obtained from stellate ganglion blocks, but in other patients time alone often seems to be the healing factor.

Lefevre (23) recommends the use of low-voltage x-ray in the treatment of "bursitis, neuritis and myositis" of the shoulder. He uses the following technique. With the patient supine and the tube placed 30 cm above the shoulder, and using 90 KVP, 4 MA and a 2 mm aluminum filter, exposure is given for 5 minutes. The exposure is repeated with the patient on his face and occasionally a third dose is given laterally. A maximum of 3 weekly treatments of 3 doses is given. He states that relief usually results from one or two treatments.

The etiology and pathogenesis of calcification of the supraspinatus tendon is reviewed by Norwich (24). He describes in detail the treatment of this condition in its acute form by multiple needling, a form of therapy that has been used with various modifications for the past 35 years or more. The rationale of multiple needling of the calcific deposit depends upon the production of local hyperemia. In addition the soft calcific deposit is allowed to "overflow its banks", disseminating it into surrounding planes for more rapid absorption. He emphasizes the importance, following needling, of immediate and continuous movements of the shoulder under the instruction of a trained physical therapist. Although pain may be increased following treatment, it is short-lived and all pain disappears in an average of 10 days. In acute cases one needling usually suffices, in subacute forms it may be necessary to repeat two or three times. Failures are due to inadequate infiltration and needling and to lack of immediate and daily shoulder motion.

(Ed. note: Excision of the deposit under local anesthesia, which consumes only a little more time than that required in the needling process, seldom increases postoperative discomfort and gives immediate relief.)

Behrend (25) condemns the indiscriminate manipulation of the "frozen shoulder" under anesthetic in an attempt to mobilize it in one sitting. The physician who utilizes this method has not intelligently evaluated the status of the ligaments, tendons and muscles surrounding the joint, and is not cognizant of the stage of inflammatory reaction of all tissues involved. Manipulation results in tearing and stretching of these weakened structures, producing minute and larger hematoma which result in new adhesions as painful and disabling as the previous ones. He divides frozen shoulder into two types; a painful and a painless one. Treatment of the former should be conservative, using minimal long-wave diathermy, various forms of local heat applications, and liberal use of sedatives and salicylates. It may take weeks to bring this phase under control and the patient must understand this fact to cooperate properly. When pain has subsided, more active therapy is indicated. After preliminary treatment with long-wave diathermy or infra-red radiation for about 10 minutes, sinusoidal current is used for a period of 15 to 25 minutes followed by massage. Mild passive stretching and active exercises are begun, and the amount of force used in the passive stretching varies with the patient's tolerance and reaction to previous treatment. Stretchings must be postponed if increased pain results. When definite improvement has resulted from this graduated form of treatment and musculature has been restored to normal, treatments may be discontinued. Spontaneous improvement will continue, but the patient should be rechecked occasionally to guard against possible flare-up.

Mason (26) reports favorable results in the treatment of "frozen shoulder" by stellate-ganglion block. Twenty cubic centimeters of 1/2 percent novocaine is injected into the ganglion once or twice weekly for several weeks. A case receiving this treatment is presented.

Other Conditions of the Shoulder

As the basis of a clinical report on common conditions of the shoulder, Larson (27) reviewed over 60 articles on this subject, published between 1944 and 1948. Calcification and rupture of the musculotendinous cuff, periarthrititis, frozen shoulder, and dislocation of the shoulder and acromioclavicular joint are discussed.

Hitchcock and Bechtol (28) focus attention on the importance of lesions of the long head of the biceps as a cause of pain and disability of the shoulder joint. Their paper supported by excellent clinical and anatomic studies convincingly demonstrates the importance of this disabling condition. Four representative cases of biceps peritendinitis are discussed in detail. They have developed a surgical procedure, used on 26 cases having this disease, with gratifying results. The method consists essentially of fixing the tendon of the long head of the biceps to the bicipital groove and resecting the portion proximal to the point of fixation. After studying the humeri of man and other primates, the authors conclude that the normal anatomical mechanics of man's biceps tendon is faulty. The intertubercular groove, during man's evolution from the ortho to the pronograde position, has shifted medially, and consequently the tendon occupies a very insecure position, subject to direct trauma and to the trauma of everyday function. In addition, variations in the depth of the bicipital groove and the angle of its medial wall, and the presence of a supratubercular ridge cause trauma to the tendon.

Fairbank (29) states that downward subluxation of the humeral head is a frequent finding following fracture of the upper end of the humerus. Radiographic evidence of this abnormality was present in 12 cases of a series of 115 fractures of the proximal humerus treated at the Manchester Royal Infirmary. Although the subluxation often disappeared spontaneously, it may persist and cause disability. He attributes the subluxation to gravitational pull against scapulo-humeral muscles which have lost normal muscle tone, and recommends the use of a triangular sling or a shoulder spica in these injuries instead of the commonly used collar and cuff sling.

To correct dropped shoulder resulting from paralysis of all shoulder muscles, Spira (30) fixes the tip of the scapula to the 6th rib. This procedure stabilizes the shoulder and corrects the abnormal inclination of the head and neck to the affected side. The scapula is fixed to the rib by notching its tip so that it forks the rib, or by passing the rib through a tunnel in the scapula. Wire loops used in his original case loosened and the method was abandoned.

Lurje (31) states that when the "upper primary fasciculus" of the brachial plexus is disrupted by trauma, the treatment of choice, as in

the case of any other peripheral nerve, is end to end suture of the severed nerve trunks after resection of neuroma and scar tissue. In many of these injuries, however, the defect between nerve ends after resection makes direct suturing impossible. Because recourse to transplants in these cases does not appear to hold much promise, he uses neighboring nerves as neurotizers, cutting the donor nerve as far away from the zone of injury as possible and attaching it to the degenerated recipient nerve. The nerves chosen as neurotizers obviously are those which can be used without further impairing the function of the extremity. He has used the following neurotizers with considerable success; the long thoracic to the suprascapular, the anterior thoracic to the musculocutaneous, and the tricipital branches of the radial nerve to the axillary nerve. Before these donors are utilized, clinical and electrophysiologic tests are made to establish that they have sufficient potential capacity as neurotizers, and to confirm complete degeneration of the recipients. A detailed description of the operation performed on a 20-year old female with upper brachial plexus injury is presented. This case illustrates successful use of the anterior thoracic, long thoracic and radial nerves as neurotizers.

Bateman (32) reports successful results from transplantation of the acromion process with its trapezius muscle attachment into the upper end of the humerus. His patient had had complete loss of shoulder abduction, with good hand and forearm function following a traction injury, which irreparably damaged the upper roots of the brachial plexus.

Butterworth and Carpenter (33) report a case of bilateral slipping of the proximal humeral epiphysis due to severe trauma. Their patient, a boy of 16, was thrown from the rear of a truck probably landing on his outstretched arms. The resulting deformity resembled bilateral subglenoid dislocation. Reduction was accomplished without difficulty by manipulation. A good range of bilateral shoulder motion was present after 20 weeks with, however, marked deltoid atrophy on the left side.

Bilateral rupture of the tendon of the long head of the biceps brachii muscle is reported by Christie (34). Surgical repair consisted of looping the tendon through the lower margin of insertion of the pectoralis major tendon and suturing it on itself. In this patient ruptures did not occur simultaneously but were the result of separate injuries occurring over a period of a year, and in both instances the injury followed the lifting of a heavy object. The author tabulates the types of treatment, and the various operative repairs used by others in the management of this disabling injury.

Rossignol (35) reports the case of bilateral congenital pseudarthrosis of the clavicle in a 22-year old girl whose main complaint was shoulder fatigue. Treatment consisted of fusion of the scapula to the 4th rib. Follow-up study 7 years later showed 75 percent normal movement of the shoulder girdle on both sides. The patient had no functional complaints.

Cervical Intervertebral Discs

Milner (36) believes that many cases of cervical root irritation from prolapsed discs and osteophytic growths are overlooked. These patients

appear to suffer from a "disease of symptoms rather than of signs". Signs may be, and probably are present, but the examiners powers of recognizing them are at fault. In addition, other injuries may be sustained simultaneously which prolapse and overshadow the effects of the latter. It is also difficult, if not impossible, to examine in detail muscles supplied by the posterior primary divisions. Again, effects may involve bilateral groups of muscles leaving no basis for comparison of the two sides. He suggests that the diagnosis and successful treatment of root lesions can be most effectively accomplished only after correlating the combined contributions of experts in the many branches of medicine concerned with the problem.

Bucy, Heimbürger and Oberhill (37) emphasize the importance of early diagnosis and treatment of cervical disc herniation. They report four cases of median disc protrusion, all occurring in males, and present a thorough discussion of the symptomatology, types of herniation, differential diagnosis, etiology and treatment of cervical disc protrusions. All of their patients were active males between the ages of 33 and 55 years, indicating indirectly that trauma is responsible for these injuries, although in only one case did symptoms definitely follow known neck injury. Whereas upper extremity involvement is predominant in lateral protrusions, in median protrusions, spasticity of the lower extremities and disturbance of equilibrium are dominant, with minimal or no neck or upper extremity disturbance. It is most important that these lesions be differentiated from multiple sclerosis, primary lateral sclerosis and amyotrophic lateral sclerosis for obvious reasons, but their confusion with a cord tumor is of little importance as both the disc and tumor are treated surgically. Treatment in the author's cases consisted of surgical removal of the protruding disc material transdurally through a bilateral laminectomy, of at least two vertebrae. In none of their cases did they feel that bone graft or other stabilizing procedures were indicated. The prognosis should be excellent in cases diagnosed and treated early. All of their patients were able to return to work and have shown steady improvement.

A review of the cervical disc syndrome and its differential diagnosis by Fields (38), scans the literature on this subject. Shoulder and neck pain is a common complaint and often a difficult problem, and frequently the diagnosis offered seems to depend upon a field of special interest of the examining physician. Thus the orthopedist, neurosurgeon, cardiologist, and general practitioner vary considerably in their statistics as to the cause of shoulder and neck pain. In recent years, there has been increasing awareness that a high proportion of these disabilities are due to herniations and other abnormalities of the cervical intervertebral discs. The author emphasizes the possibility that any disease process of the cervical spine or shoulder may cause spasm of the scalene muscles and thus supports the belief of Nachlas, Raney and others that most cases of scalenus anticus syndrome are secondary to cervical intervertebral disc abnormalities.

The successful results obtained by various British surgeons in the manipulative treatment of the neck for cervical arthritis, has encouraged LeVay (39) to try this method in cases presenting unequivocal evidence of prolapse of the cervical disc. He treated six patients by this method

with immediate and dramatic recovery in five cases. The sixth patient was unaffected by manipulation but was relieved of symptoms following a 72-hour period of skull traction. He states that manipulation is indicated only if pain is present, and is not indicated for paresthesia alone. The fear of producing cord symptoms, he states, is without grounds in purely monoradicular syndromes. After observing and performing many cervical manipulations, he knows of no patient in whom cord symptoms developed following this therapy.

Headache, as a common symptom of cervical disc lesions, is discussed by Raney and Raney (40). They report 4 cases of intervertebral disc pathology in which headache was the chief complaint. (In one case this was not admitted by the patient until after the disc was removed). The headache produced by pathologic changes of the cervical disc may be constant and vary only in intensity; it may be periodic, presenting itself only during certain activities of the patient; it may be so mild as to pass unnoticed until exacerbated by nervous strain, muscular fatigue or during the menses when a reduced pain threshold occurs; it may be of short duration occurring as a stinging, tingling sensation radiating over the occipital or parietal regions. At times the patient may complain of headache when actually the discomfort is in the neck. The extreme variation in intensity, frequency, radiation, projection and location, prevents a clear definition or classification of this symptom. Examination of the patient having headache due to a cervical disc lesion reveals characteristic signs. Neck muscles may be spastic with cervical scoliosis or lordosis, or the neck may be maintained in a slightly tilted or rigidly fixed position. More important are the areas of localized tenderness in the suboccipital, cervical, shoulder and elbow regions. No detectable motor, sensory or reflex changes may be present. If present, they indicate later stages of disc protrusion, and the associated shoulder and arm discomfort overshadows any headache that may be present. An explanation of the mechanism producing headache as a result of disc pathology rests on present knowledge of referred pain, diffusion of pain and mental projection of pain, and not necessarily on evidence of direct neural connection between the disc and the area in which the patient believes the discomfort to be located.

Jackson (41), in a review of 200 cases of cervical root irritation, found that half of them had complained of intermittent headache, many having been treated for migraine. A history of trauma was given in 94 percent of the cases, with symptoms dating from the onset of trauma to many years following injury. The discomfort varies from pain radiating upwards from the posterior cervical region, or base of the skull, to the side of the head and mastoid region or ears, to blurring of vision, dizziness and nausea. Most of the patients complained of being awakened in the early hours of the morning by the onset of headache. X-ray examination of the cervical spine, using the technique described by Davis, disclosed obliteration of the normal forward curve in 70 percent of the cases with 20 percent showing segmental reversal of the curve. Ninety percent showed forward subluxations and 56 patients had backward subluxations which meant that a large number had both forward and backward displacements. Thirty-five percent showed x-ray evidence of ruptured discs. Treatment was conservative in all cases. Because in so many patients, onset of discomfort in the early morning hours indicated improper sleeping posture, the author devised a "contour" pillow fitting into the natural curve of the

neck, which she states has been the greatest adjunct in the treatment of cervical root irritation.

Cervical Cord Injury

Barnes (42) reported 22 cases of cervical spine injury. Fifteen of his patients had flexion injuries, 8 of these being dislocations, 4 crush fractures of the vertebral body and 3 acute retropulsion of the intervertebral disc. Six injuries were of the hyperextension type in patients with arthritic spines. In one case the injury consisted of a dislocation due to hyperextension force. Of interest is the age group into which the flexion and the extension injuries occurred. In the flexion group the oldest patient was 50 years of age, in the hyperextension group all injuries were incurred in patients over 50 years of age. Elderly patients are prone to extension injury because of (1) the tendency, in advancing years, to kyphosis of the dorsal spine with compensatory cervical lordosis, and (2), the loss of normal cervical mobility due to arthritic changes in the joints and ligaments which prevents a protective flexing of the neck in the event of a fall. These patients show surprisingly little bone or spinal cord injury, yet paraplegia and death within a few days occurred in 5 of the 6 cases treated by the author. He describes the mechanism of injury as being an extension force producing rupture of the anterior ligament with or without avulsion of a small flake of bone from the upper margin of the inferior vertebra. Sudden traction force is applied to the cord during the period of hyperextension and the return to normal alignment when the striking force is removed.

Taylor and Blackwood (43) report a case of hyperextension injury to the cervical cord which supports the observations of Barnes. They believe that in those cases of paraplegia following trauma, in which there is little or no x-ray evidence of bone injury, a hyperextension injury should be suspected.

In an editorial, Jefferson (44) comments on the concept of Barnes, Taylor and Blackwood as to the mechanism of extension injuries to the cervical cord. He believes that their conclusions will probably be substantiated by other observers. However, "the real problem of spinal injury is not altered materially by change of opinion as to what the agent of injury may be".

That flexion type injury to the cervical cord may be produced without roentgenologic evidence of fracture or dislocation is illustrated in a case report by Gordon (45). His patient developed a myoclonic phenomena in the form of myokymia and fibrillary contractions of the flexors and extensors of the arms. This unusual muscular phenomena which was noted following examination of his patient immediately after injury, was still present in a follow-up examination 11 years later.

Cervico-Brachial Nerve Irritation

Dedichen (46) notes that the patient with shoulder pain of sudden onset, with radiation down to the elbow, will often show, especially in early

stages of the condition, findings characteristic of localized nerve root irritation i. e. hyperesthesia in C4-5 area, exaggeration of the deep reflexes of the arm, diminution of the abdominal reflexes on the same side, intensification of pain on flexion of the neck to the side of pain and a positive jugular vein compression test. This pain may produce a typical picture of humeroscapular periarthrits, with calcification of the rotator cuff. He believes the formation of calcium to be secondary to reflex arterial constriction as the result of the irritation which results in tissue degeneration.

Following a detailed anatomic study of the scalene muscles and associated structures, Kirgis and Reed (47) were able to demonstrate several factors which apparently are of importance in the production of the scalene syndrome. 1. Irritation of the lower components of the brachial plexus by elevation of the first rib through activity of the scalene muscles. 2. Irritation of the adjacent nerve root and subclavian artery by compression of the contracted posterior components of the anterior scalene muscles. 3. Irritation of the brachial plexus, especially the 7th and 8th cervical and 1st thoracic nerves, by traction across the anterolateral margin of a spastic medial scalene muscle. 4. Irritation of the lower brachial plexus trunk by pressure anteriorly of the scalenus minimus muscle or the vertebrocostal ligament. They do not believe that purely anatomic relationships are responsible for spasm of the scalene muscles, but that these relationships may be so patterned that development of symptoms follows spasm of these muscles. In cases where surgical treatment is indicated, they advocate complete resection of the major portion of the scalenus anticus muscle, when these structures are present. Anterior scalenotomy alone has frequently yielded poor results because it has constituted the treatment of only one of the possible manifestations of a more serious disease.

Telford and Mottershead (48) believe that although the diagnosis of a pressure lesion at the cervico-brachial junction is usually simple, the causes of pressure are so varied and obscure that it is often difficult or impossible to predict them. For this reason, when surgery is advised, the authors believe it should be performed through an incision generous enough to allow thorough investigation of the causes of pressure. Their belief is based on the clinical and surgical findings in 122 patients personally treated. At surgery symptoms were found to be due to the presence of a cervical rib in 70 cases, to abnormal disposition of the scalene muscles in 8 cases, to deformed thoracic outlet in 8 cases, to pressure of fibrous band in 12 cases, to cancellous osteoma in 2 cases, and in 5 cases there was no obvious cause for symptoms. In the remaining group, which they considered complicated, 15 showed well developed cervical ribs with extensive arterial thrombosis, and three of these had aneurysmal dilatations of the subclavian artery. In their opinion, too much emphasis has been placed on the scalenus syndrome. When pain is due to anterior scalene muscle pressure, the pressure is passive and mechanical and is not the result of spasm, injury or disease of this muscle. The costo-clavicular syndrome has also been over-emphasized. Formalin hardened cadaver and fresh post-rigor bodies were studied, and in no instance could the subclavian artery or brachial plexus be compressed between clavicle and rib. Thrombosis of the subclavian sympathetic nerve fibers, and the presence of aneurysm is explained as the result of segmental vasomotor paralysis of the artery.

Judovich (49) emphasizes the importance of distinguishing between a primary scalene syndrome, in which symptoms originate and are due to intrinsic disturbance of the muscle, and a secondary scalene syndrome, resulting from reflex spasm of the muscle produced by irritation of structures in the shoulder girdle or by disturbance of segments innervating these structures. Surgical procedures give complete relief in the former type, and only partial relief in the latter. The symptoms of the two types may be identical, and in the author's opinion, the most dependable method of differentiation is a modification of the novocaine infiltration test introduced by Gage in 1939. One and a half to two cc. of 1 percent novocaine is injected directly into the muscle belly, using 3/8 to 1/2 inch needle to prevent too great a depth of injection. Within 3 minutes, in primary cases, response is dramatic, and the more rapidly the symptoms disappear, the more likely a primary spasm exists. The neck and shoulder is then re-examined the moment pain is relieved. The presence of pain in percussion of the cervical spinous processes, or on motion of the cervical spine during the relief period, suggests a secondary scalene syndrome. Repeated novocaine infiltrations are recommended, and the results evaluated before final differential diagnosis is made. Frequently these repeated injections will produce sustained relief of symptoms in primary cases.

DePalma (50) states that the treatment of the scalenus anticus syndrome should be directed both to the etiologic factors and to the contracted scalene muscle. Mild forms of the syndrome will respond to conservative measures, such as postural exercises, shoulder and back supports, change of occupation, and rest augmented by sedatives and procaine injections into the muscle belly. When conservative methods fail, division of the scalenus anticus muscle is the treatment of choice. However, because many patients refuse surgery, or because surgery is contraindicated the author has substituted skeletal traction on the cervical cord. In his series of 17 patients in which conservative therapy was augmented by traction, all but one was relieved of pain.

In a similar vein, Donald (51) reports that a majority of patients with scalenus anticus and cervical rib syndromes will respond to conservative therapy. This treatment includes correction of posture, rest, avoidance of strain, physical therapy and analgesic drugs. In about 25 percent of cases symptoms are unrelieved by conservative therapy, and in these cases only is surgery warranted. Over a 10-year period he operated on 42 patients with this syndrome. On 8 occasions a cervical rib was demonstrated, and in these patients symptoms of brachial plexus and subclavian artery compression were, in general, more severe than if the anomalous rib was not present. Pain is usually the greatest cause of disability and is usually felt along the distribution of the internal cutaneous, ulnar and median nerves. It varies in intensity and may be sharp, but more commonly is of a dull aching nature, and may involve the entire arm, shoulder and neck regions. Circulatory disturbances are usually mild unless a cervical rib is present, in which case marked changes, including gangrene of the distal extremity, results. Frequently the scalene muscles are tender to pressure. In chronic states, atrophy of the

interosseous muscles may be seen, and the grip is noticeably weak. In the differential diagnosis, protrusion of a cervical intervertebral disc, cervical arthritis, subacromial bursitis and psychoneurosis, cause the most difficulty.

Haggart (52) treated 20 consecutive patients with cervicobrachial pain by conservative methods, and classified the results as excellent in 5 cases, good in 12 cases, and fair in 3 cases. Because of the common characteristics of cervical pain with radiation to shoulder and arm, these cases were grouped together although the diseases were heterogeneous. There were 3 cases each of cervical rib, protruded disc, degenerative arthritis, scoliosis, scalenus anticus syndrome, costoclavicular syndrome and hyperabduction syndrome; and one patient with posttraumatic symptoms. Most of his patients were treated on an ambulatory basis. The principal treatment consisting of postural exercises was directed toward neck and shoulders. Occupational habits were investigated, and if habits were found that contributed to faulty posture and muscle stress and strain, suggestions were made to correct or omit them. Vitamin B complex was administered three times daily in those patients, usually female office workers, where vitamin B deficiency was present. Mild analgesics were prescribed as an aid in breaking up the vicious cycle of pain. The age of his group of patients ranged from 24 to 60 years, with an average of 39 years. The ratio of females to males was 3 to 1. In only 15 percent of the cases did occupation appear to be unrelated to symptoms. Using conservative treatment he was able to restore all of his series of patients with varying degrees of disability to usefulness, 17 with good and excellent results, the average follow-up period being 15.3 months.

Bograd and Peters (53) base their diagnosis of scalenus anticus syndrome on the effect of novocaine injection into the muscle. When temporary relief of symptoms is obtained following injection, precautions being taken to inject only the muscle belly, they feel that scalenotomy is indicated. It is their opinion that conservative treatment yields no better results than no treatment at all, as spontaneous remissions of symptoms are common. They present 3 cases in which they performed scalenotomy. The report does not include a follow-up study.

A case reported by Jonas and Rise (54) illustrates the inadequacy of scalenotomy alone in the presence of prominent cervical ribs. Their case is also unusual in that bilateral neuropathic changes in the elbow joints resulted from injury to sympathetic nerve trunks passing over the abnormal ribs.

Stevenson (55) reported 12 cases of scalenus anticus syndrome seen in a 12-month period. Conservative therapy produced partial to complete relief of symptoms in 9 cases. Complete relief in the remaining 3 cases resulted following anterior scalenotomy.

Complete relief of symptoms was obtained in 3 cases reported by Levi (56) following division of aberrant fibers of the scalenus medius muscle. In each instance the aberrant fibers, partially muscular and partially fibrous, passed anterior to the brachial plexus and inserted posterior to the subclavian artery on the first rib. The muscle formed a rigid aperture through which a lower branch of the plexus passed. Cervical ribs were not present on x-ray examination in any of his cases.

(Ed. note: It is apparent that there is still considerable disagreement as to the significance of the scalene muscle group in the production of cervicobrachial pain. The studies of Telford and Mottershead, based on an unusually large series of cases, are significant. Their report probably comes closer to the solution of this problem than any other paper published in 1948.)

Batchelor (57) reports a case of malunion of the left clavicle in a woman 38 years of age, who developed pain in the shoulder radiating to the ulnar aspect of the forearm and hand. Physical findings consisted of atrophy of the arm musculature, decrease in temperature of the hand, and a reduction in radial pulse volume as compared to the normal side. He attributed the symptoms to costoclavicular compression.

During the routine chest examination of 2619 apparently normal applicants for position, Pomerantz (58) noted the presence of a systolic murmur over the subclavian artery in 21 individuals. All of the applicants were of Mexican extraction. The first 11 cases were passed over without special examination, because the murmur was considered functional. A more detailed study was performed on the remaining 10 cases in an effort to determine a possible relation of this murmur to extravascular compression or obstruction. From this limited clinical material, after careful blood and pulse pressure studies, he felt that definite extravascular obstruction of the subclavian artery was present. This obstruction was usually related to position of the arm, and a characteristic postural attitude. Because progressive obstruction occurred with increased abduction of the arm, presently recognized forms of the scalenus anticus syndrome seemed to be excluded, as an etiologic factor. The absence of carotid artery transmission and the variability of obstruction with arm position, excluded an intrinsic vascular mechanism as a cause for the murmur. Subclavian compression as a cause was discarded because the murmur was frequently present with the arm at 45 degrees, the phase at which the clavicle is not in close approximation to the first rib. Because all of the patients presenting this murmur were asymptomatic and surgical exploration to determine the cause was unjustified, the mechanism producing compression necessarily was a matter of conjecture. However, by title the author implies that the murmur was caused by an asymptomatic form of scalenus obstruction or some other compressions of the arterial trunk, such as that described by Wright.

Cliffton (59) reports a case of dysfunction of the upper extremity in a 35-year old soldier. His symptoms of pain in the arm, numbness, tingling and weakness of the hand had been present for five years following a fracture of the clavicle. At surgery a markedly hypertrophied subclavius muscle was found to be almost completely occluding the axillary vein as this vessel passed beneath it. Thrombosis of the vein was not present, and simple incision of the muscle at the point of pressure resulted in relief of symptoms and improvement in function of the extremity.

Bledin (60) briefly reports a case showing paralysis of the musculature of the right forearm and hand, innervated by the ulnar nerve. Although roentgenograms did not show a definite cervical rib, there was a shadow, less dense than bone, extending from the 7th cervical transverse process downwards toward the first rib bilaterally, which he was inclined to believe was the etiologic factor.

A disorder characterized clinically by a peculiar combination of painful shoulder disability with homolateral swelling of the hand is discussed in an article by Steinbrocker, Spitzer and Friedman (61). This shoulder-hand dystrophy of unknown etiology was seen on 11 occasions in their series of 42 cases of reflex dystrophy of the upper extremity. In the other cases, definite etiologic factors, among them, myocardial infarction, trauma, hemiplegia, herpes and arthritis, were responsible for the reflex sympathetic changes. Although the precipitating factors vary, and in 11 of their cases were undetermined, the clinical picture produced is much the same, i.e.; a painful shoulder of sudden or gradual onset, followed in several weeks by uniform swelling, pain and stiffness of the hand and fingers. After a period of 3 to 6 months in progressive cases, pain in the shoulder subsides and the hand swelling resolves. During this second stage stiffness and flexion contracture of the fingers becomes more pronounced and atrophy of the subcutaneous tissue and intrinsic muscles of the hand more noticeable. The previously elevated cutaneous temperature subsides. Osteoporosis, patchy in nature, which may not have been visible during the early stage, is strikingly noticeable at this time. The final stage is characterized by progression of trophic changes in the hand, further decrease in skin temperature and diminution of blood flow to the extremity. Bone atrophy becomes widespread and diffuse in hand, forearm and arm. The mechanism producing the shoulder-hand syndrome, regardless of the precipitating factor, is believed to be "a vicious circle" mediated through an internuncial pool of active stimuli in the cord. This hypothesis is based on the favorable response, in early stages, to interruption of sympathetic pathways by stellate and upper dorsal ganglion block or surgery. Surgery, however, is reserved for those cases where repeated sympathetic blocks give only partial or temporary relief of symptoms.

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SECTION 17

HAND AND ELBOW

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Injuries

Browne (1) discusses "Effective Procedures in the Treatment of Injured Hands to Prevent Crippling Deformities." The management of a hypothetical case of hand injury from the trauma to the ultimate restoration of function is presented in minute detail. Each of the following is described at length: diagnosis of injured structures, preparation for operative procedure, further examination before cleansing the wound, debridement and enlarging the wound, approximation of viable ends of divided structures, the dressing, and finally rehabilitation. The author emphasizes that a contaminated wound must be made clean; an open wound must be converted into a closed one. Other procedures, depending upon the condition of the tissues injured and the methods available for establishing continuity of these tissues, may and should be carried out when safety permits.

Thompson (2) presents an outline of the principles of early management of hand injuries. Protection against added infection and protection against added tissue damage and deformity are the primary issues. The outline is submitted with the commendation of the Committee on Fractures and Trauma of the American College of Surgeons at the instigation of the American Society for Surgery of the Hand to familiarize the general profession with these principles.

With well chosen case reports Mason (3) emphasizes many fundamental principles with regard to treatment of open wounds of the hand. Some interesting comment occasioned by the case reports, is made upon the following considerations: 1. The decision as to whether or not tendon repair should be taken as a primary operation. 2. Manner of enlarging the wound to obtain adequate exposure for repair of nerves and tendons. 3. Use of a blood pressure cuff to procure a bloodless field. 4. Method of handling avulsed and crushed skin. 5. Value of compression dressings. 6. The use of a splint following surgery of the hand. 7. Interval between time of wounding and the primary care and the indication for primary closure of a wound. 8. Immediate application of a pedicle flap. 9. Skin which has been subjected to severe crushing and tearing and 10. Secondary wound closure.

Detro (4) discusses the important factors in history taking, physical examination, and some of the pitfalls in treatment in the form of primary care, to extensively injured hands. Some pictures of the before and after variety are presented. He also includes the rationale of treatment of various types of hand fractures.

Mason (5) discusses in detail the treatment of both early and late open wounds of the hand. He discusses all of the basic principles and gives his

preference for primary closure and tendon and nerve repair if circumstances permit and the injury can be cared for within a four hour deadline. He discusses the importance of good first aid, that is, control of hemorrhage by compression, coverage of wounds with sterile dressings and avoidance of secondary contamination from the nasal passages and probing, etc. He describes how to recognize dead and dying tissues which have to be excised during the meticulous debridement. He also describes his method for tendon and nerve repair preferring untreated silk suture material on a swaged needle.

Duncan (6) discusses the anatomy, indications for tendon repair and evaluation of results in a series of 42 consecutive cases of repair of flexor tendons of the hand divided in the flexor sheaths. Primary and delayed repairs are discussed with immediate repair being undertaken where possible in which nearly 50% were classified as good results. A small series of cases of divided pollicis longus tendons is included. He also presents the results of investigations into the pathology of mallet finger, recording the exact site of tear (fracture at base of terminal phalanx, and non fracture type (a) avulsion of the tendon from the base and (b) avulsion proximal to this level) and synovial involvement which after healing may result in adherence to bone and a poor result. A fully flexed terminal phalanx without any power of extension is presented as the main indication for operation.

Mason (7) discusses basic principles pertinent to secondary closure of wounds of the hand. He, refers of course, to those injuries that cannot be closed primarily because of existing circumstances. Conversion of an open wound into a surgically clean wound at the earliest moment is to be strived for. Debridement, or removal of dead and dying tissue can be performed early or late. Wounds, of course, are left open if danger of locking up infection exists. Cover of the cleansed and debrided wound with a voluminous dressing and putting the part at rest with a splint are important aspects of therapy. He describes what he calls a "universal hand splint", which looks like a derby hat with a forearm attachment, over which the hand is moulded. The hand is then examined preferably in the operating room 4-6 days later and secondary closure performed if appearance permits. Four case reports are included.

Van Demark (8) calls attention to the fact that although transscapho-perilunar dislocation of the carpus is relatively frequent, it has received little recognition as an entity. He notes further that the lunate and proximal scaphoid fragment have been excised under the erroneous impression that they were dislocated. Emphasis is laid upon recognition. The author believes that early closed manipulation and reduction is the treatment of choice in this type of injury.

Waugh and Yancey (9) note the rare occurrence of carpo-metacarpal dislocations with particular reference to simultaneous dislocation of the bases of the fourth and fifth metacarpals, and with an extensive review of the literature, 2 such cases are reported. Attention is called to their importance in maintaining the proper mechanics of the hand and the restoration of muscle balance. One case presented was reduced by closed and another by open reduction, the latter being held in position by dual Kirschner wire fixation of the fourth and fifth to the third metacarpals.

Sampson (10) reports three cases of isolated dislocation of the lesser multangular bone. In searching the literature, the author was able to find only 8 previously reported cases. Of the total of 11 reported cases, 10 were dorsal, 1 volar. The mechanism of injury was strikingly similar in each of the author's cases. The diagnosis is established by clinical examination, by roentgen examination, of which the routine posteroanterior view is of the most value, and by careful comparison with roentgenograms of the untraumatized, presumably normal wrist. No rule of treatment is established. These methods were mentioned; closed reduction, open reduction and excision.

Immerman (11) reviews the literature and presents a beautifully illustrated case report of dislocation of the pisiform. In cases which do not respond to splinting and in chronic cases, surgical excision of the pisiform is recommended.

Howie (12) presents a method of treating mallet finger with the proximal interphalangeal joint in flexion. It involves the use of ordinary plaster bandage, applied in two sections, the first to the proximal two phalanges and the second to the distal phalanx. The two sections are then joined with more plaster bandage, the distal interphalangeal joint being held in hyperextension.

Sandison (13) discusses some of the basic principles of treatment of supracondylar fractures in children and adults and their complications, such as delayed ulnar palsy, Volkman's ischemic contracture, and decrease or increase in carrying angle. He stresses the need for recognition and open reduction with wire fixation in capitellum fractures in children. Dislocation of the head of the radius is to be watched for closely. Where comminution of the radial head exists, excision and removal is recommended. Continued painful elbows presenting evidence of traumatic arthritis should be considered for arthroplasty or fusion in a position most suitable to the patient.

Railton (14) reports a case of compound dislocation of an elbow joint, uncomplicated by fracture. The humerus protruded thru a skin laceration posteriorly. Debridement was performed with suture of the posterior capsule, the torn triceps insertion and anterior transplant of the ulnar nerve. The skin was closed secondarily several days later by double pedicle shift and split thickness skin graft. End result of function is not reported.

Milch (15) discusses the incidence of rupture of the biceps brachii at various levels and reports a case of solution of continuity at the muscle's insertion. Operation was performed and because of degenerative fraying at the distal tendinous portion repair could only be accomplished by using a fascia lata tube replacement. The proximal portion was sutured to the lower end of the biceps and the lacertus fibrosis, the distal end drawn together with a silk thread and pulled down to a hole prepared in the radius to which it was tied, together with the remnants of the biceps insertion. Plaster immobilization was left on for three weeks, and gentle active and passive exercises commenced at the end of nine weeks. At the end of four months powerful supination was possible and the patient returned to his former occupation as a truckman.

Tanzer (16) stresses the importance of immobilizing the burned hand in the functional position from the very onset. Early replacement of constricting

or unstable scars is most important in restoring proper nutrition and avoiding contractures. Appropriate elastic splinting should be used not only to prevent contractures but also to correct contractures if they develop.

Marks (17) presents a case of trauma to the wrist producing a compound perilunar dislocation of the carpus and anterior dislocation of the wrist. Despite early debridement, suppuration supervened, delaying a wrist fusion procedure. When this was performed (no mention of how long healing had existed prior to undertaking this procedure), a pocket of encysted pus was encountered. A bone graft from the tibia was used and with antibiotics postoperatively, healing per primum ensued. It was noted that good function of the hand, except for a stiff thumb, resulted.

Ratliff (18) presents a review of forty five cases of mallet finger revealing that the subjective end results are good, but, contrary to certain authorities, only 44% healed in a perfect anatomical position.

Infections

Pilcher and Dawson (19) discuss the principles and practice of the treatment of infections of the fingers and hand. Acute infections of the skin and subcutaneous tissues of the fingers and hand are treated by immobilization during the diffuse phase of the infection. Operation is delayed until purulent material is localized and its sole function is its evacuation. Paronychia, a subcuticular infection, can be adequately treated without sacrifice of the healthy nail. Incisions to relieve tension in the stage of cellulitis is condemned and together with delay in starting treatment are causes of prolonged disability. Systemic penicillin is used to control spread of infection and locally to accelerate healing. It is thought to delay separation of slough but to prevent spread of bone infection.

Loudon, Miniero and Scott (20) make a preliminary report of sixty nine consecutive cases of infections of the hand, describing their classification, pathology, pre-operative, operative and post-operative treatment. Where possible, they practice complete excision of dead and dying tissue with primary closure, thereby decreasing healing time considerably. Where primary closure is not possible, subsequent pinch grafts are used. Chemotherapy and immobilization in plaster of the affected part only are used in conjunction with excision and primary suture technique which must be meticulously complete. The possibility of recurrence of local infection proved not to be the main danger. Extensive exposure, however, increases the possibility of damage to important structures, particularly if carried out by inexperienced surgeons.

Van Demark, Koucky and Fischer (21) discuss peritendinous fibrosis of the dorsum of the hand, persistent swelling of the dorsum of the hand occurring shortly after local injury being the predominant clinical feature. In severe cases, the back of the hand has a smooth stretched appearance. Normal bony landmarks are absent and the swelling is firm. Such a swelling may persist for weeks or months. There is inability to flex the fingers while motions of the thumb are normal. A dull pain, increased by local pressure is noted. X-ray findings are negative. In two cases reported, pathological specimens revealed evidence of old and recent hemorrhage with fibrous

tissue proliferation and organization in the area around the extensor tendons. The tendons themselves are also infiltrated by fibrous tissue. Numerous forms of treatment have been suggested.

Luckey and Moon (22) quote Kanavel (23) in mentioning three types of edema of the hand, 1. recrudescing edema and pain at site of trivial injury, 2. massive edema of entire extremity with or following infection, 3. the hard edema of the dorsum of the hand after injury. Several theories as to the etiology are mentioned including circulatory obstruction, inflammation or a combination of the two. Case reports are given of two young Army men who suffered trauma to the dorsum of the hand followed by hematomas and subsequent hard painful edema and limitation of motion of the fingers. Surgical excision of dense, fibrous, cartilage-like masses was carried out in both cases after conservative measures afforded no relief. Some residual pain and limitation resulted, however. No definite conclusions were reached as to the cause of the edema. The individual predilection to keloid formation was considered and seemed to explain to a point why the picture occurs in some injured hands and not in others. The authors feel that the excision of the dorsal fibrous mass is the treatment of choice as spontaneous regression is not likely.

Nach and Lohman (24) report a case of acute arterial insufficiency with resultant gangrene of the fingers resulting from thrombosis of the radial and ulnar arteries following self-administered codeine injection. Other cases of arterial thrombosis following trauma to an extremity as described in the literature are mentioned. It is postulated by the authors that the trauma of the needle initiated the thrombosis. This is a hitherto unreported type of complication occurring in narcotic addicts.

Non-suppurative tenosynovitis of the tendon sheath of the extensor carpi ulnaris and its clinical picture is presented by Dickson and Luckey (25). The patient usually has a twisting wrist injury followed by pain deep in the wrist joint and oftentimes swelling about the distal end of the ulna. The pain may be aggravated by all wrist motions. Numbness and tingling along the dorsal cutaneous ulnar nerve may be present. There is tenderness along the course of the tendon as well as grating on motion of it. Edema of the surrounding soft tissues was observed in all cases. At operation, at which the tendon sheath was incised and not resutured, the sheath was found to be thickened and hyperemic.

Bonnin (26) briefly discusses chemotherapeutic and antibiotic therapy in infections in the hand. Purulent tenosynovitis, the anatomy of the tendon sheaths, bursae and spaces of the hand and appropriate incisions for adequate drainage are described. Sites of election for finger amputations at various levels is also presented.

Reconstruction and Plastic Procedures

Leibolt (27) gives a recapitulation of the general principles involving reconstruction of the hand by surgery. The general methods of bone repair, plastic surgery, procedures to improve joint function, principles of nerve and tendon repair and operations to establish opposition of the thumb are briefly outlined.

Barsky (28) reports a technique, applicable to certain special cases for thumb restoration, by means of finger transplantation and nerve suture in stages. Stereognosis can be achieved which flaps taken from distant regions cannot do. Other methods in cases of partial, subtotal and total loss are also described. Of the nine cases presented only one developed a complication, which was ulceration of the distal end of the thumb tube, attributed to too early severance of the tube without progressive clamping off of the circulation. The use of different type bone grafts is discussed. The author expresses his preference for a curved portion of the ilium because of more rapid healing. A practical work prosthesis is also demonstrated in photographs.

A case report of reconstruction of a new thumb by tubular pedicle and bone cartilage graft is presented by Hardin (29). It was stated that the patient has a useful extremity with a thumb for opposition. Evaluation of sensation, viability, and motion has been observed over a seven month interval.

Weckesser (30) gives a case report of traumatic amputation of the distal portion of a right thumb in which immediate reconstruction was carried out by means of abdominal tube pedicle flap followed by iliac bone graft.

Nieto Cano (31) presents a case report of a patient who lost the distal two phalanges of each of four fingers on a hand. Lengthening was performed by iliac bone graft and skin replacement with skin from the chest. Except for the loss of the bone graft applied to the index finger the results produced were satisfactory functionally. Pictures of the end result included showing the patient tying his shoelaces, writing, strumming a guitar and dealing cards.

Tanzer and Littler (32) state that a satisfactory reconstruction of the thumb should meet three requirements: 1. sufficient forceful flexion and extension to permit grasping, 2. opposability of the tip of the reconstructed thumb to the pulp of at least one digit, 3. tactile sensation at its tip. They present methods for the reconstruction of subtotal or total loss of the thumb by transposition of an adjacent digit, meeting the aforementioned requirements, and report seven cases. In practically all cases, the intervening defect produced by migrating another digit requires a pedicle flap. They state, also that it is preferable to perform the transposition and bony fusion in separate stages in order to obtain more accurate positioning of the reconstructed thumb. Following fusion, further revisions in the nature of tendon transplants, grafts, or tip shortening is frequently necessary. Apparently a damaged digit can often be more effectively employed in reconstructing a thumb than in attempting to restore its usefulness as a finger.

According to Gill (33) the first prerequisite for successful reconstruction of bone is adequate skin coverage, which may be obtained by primary closure or pedicled skin grafts but not by split grafts. The problem of residual stiffness is partially solved by practicing atraumatic technique, by the use of massive pressure dressings and by the use of internal fixation with Kirschner wires instead of plaster casts. Iliac bone is most often used as grafts in bridging defects, formation of struts and arthrodesis. The metacarpal shift is most useful in most hands with a loss of the long or index metacarpal and digit. This procedure eliminates the awkward crossing

of the fingers upon flexion. Other types of reconstruction of bone include grafts from amputated fingers and arthrodesis of the interphalangeal joints.

Ruch (34) discusses three recognized methods of reconstruction of the thumb following its loss: 1. Rotation of an adjacent digit into the position of the thumb, 2. Transplantation of a digit from the opposite hand or foot, 3. Formation of a new member using a pedicle graft for soft tissue, and at some stage implanting a bone graft. The author emphasizes certain refinements utilizing the latter technique along with a case report and illustrations of the various steps in the method.

Graham and Riordan (35) have used the heads of the 4th and 5th metatarsals as transplants to restore function of a destroyed metacarpo-phalangeal joint successfully. Excellent results in five well illustrated cases are presented. Emphasis is placed upon: 1. the importance of excising all cicatricial tissue from the site to receive the transplant; 2. the reestablishment of complete intrinsic muscle control of the proximal and distal joints of the finger; and 3. prevention of anterior subluxation by reconstructing the extensor mechanism and by splinting the finger in complete extension during the period of immobilization. The transplant is fixed in place by 2 Kirschner wires through the adjacent metacarpals.

Blake (36) groups thumb injuries and operations into three groups depending on the degree of tissue loss. I. with a functioning MP joint requiring only the removal of painful or adherent scars to give a good opposition stump. II. where the MP joint is lost, requiring some form of elongation to permit a firm grasp and III. where there is total loss of all thumb elements complete digit transference or migration of the index finger is necessary. A reconstructive procedure in a group II case is described in which an abdominal tubed pedicle skin flap was transferred, followed in a month by stabilization of the skin thru the insertion of an iliac bone graft. Gentle use of the thumb is allowed as soon as there is x-ray evidence of union of the bone graft.

Moore (37) is of the opinion, after clinical appraisal of many war injuries to the hands and many types of operations to restore lost prehensile activity, that the method of choice in the majority of cases is pollicization. Any operative procedure that claims to restore opposition, the author feels, should fulfill the following conditions: 1. Prehensile ability must be restored, 2. It must be strong so that an adequate grip is obtained, 3. It must retain or restore normal sensation in the new thumb. Many methods used to restore opposition are discussed.

Cuthbert (38) reports a completed case of pollicization of the index finger. The author states that the two prime indications for use of this method as opposed to lengthening of the thumb are: 1. Absence or shortness of proximal stump of the thumb. 2. Damage and resultant functionally disabled index finger. He stresses the importance of maintaining a normal nerve and vascular supply and preserving long flexor and extensor tendons.

The importance of physiotherapy and occupational therapy in the post-operative treatment of tendon grafts and tendon transfers in the hand is noted by Phalen (39). The author's description of the various types of tendon transfers should prove useful to physiotherapists who contribute to a

functional result, but who may not have had the opportunity of visualizing the operative procedures concerned.

Bruner (40) states that the tendons available for transfer to the first dorsal interosseus are: the extensor indicis proprius, a flexor digitorum sublimus and the extensor pollicis brevis. He has used the latter successfully and he states that it is particularly indicated in ulnar nerve lesions where recovery is doubtful. Its use is not disabling, it has a favorable angle of pull, it is long enough to be used without lengthening by graft and it is strong enough to restore function.

Van Demark (41) describes the tendon transplantation of Sir Robert Jones and Billington for irreparable radial nerve palsy. For three weeks postoperatively the hand is immobilized in a plaster splint with the wrist dorsiflexed, fingers extended and the thumb extended and abducted. Mobilization is begun thereafter.

Kirklin and Thomas (42) evaluate 75 cases of tendon transplants to regain thumb opposition. Essentially 6 basic methods are described and evaluated by table as to excellent, satisfactory and unsatisfactory results. Apparently all of the methods are capable of giving good results under various circumstances and careful evaluation of the function of the entire hand. Their method of choice under permitting circumstances was the use of the flexor digitorum sublimus of the fourth finger transplanted with direct insertion into the thumb on its lateral side at the base of the proximal phalanx after having wrapped it around the flexor carpi ulnaris tendon near the latter insertion.

Pulvertaft (43) gives a brief and concise review of the physiology of tendon repair, principles of treatment and general technique of operative repair. A discourse on tenolysis is also presented together with an analysis of 130 examples of tendon repair and tenolysis operations in an attempt to evaluate results.

Burman (44) discusses in detail the kinetics of the normal thumb, and its kinetic disturbances. He states that the neutral position of the wrist gives best use of the fingers and thumb. The advantages of transplanting the extensor carpi ulnaris to give abduction of the thumb for various conditions are propounded and recommended as 'one of the standard tendon transfers'. The operative procedure is described in detail together with case reports with pictures.

Stack (45) states in a brief paper that 7 patients, having been followed for a period from 10-13 years, who have had excision of both the carpal scaphoid and lunate presented most favorable results from the standpoint of strength, alignment and range of motion of the wrist. This "can be expected if the two bones are removed as primary treatment following fracture and dislocation". He further states that where minor arthritic changes have developed the limitation of motion will probably not be overcome but reasonable assurance can be given that pain will be relieved and further change will not take place.

The commonly observed pronounced degenerative arthritic changes about the radial styloid in old cases of non-union of the carpal navicular provides

a case for discussion by Barnard and Stubbins (46). Other aspects of the role of the radial styloid are discussed in this type of surgery. The authors excised the radial styloid in 14 cases and in 7 cases utilized the fragment, largely cancellous, for bone grafting. They stated that 9 out of 10 cases had good end results although the follow up period was only two and one-half years.

Butler (47) reports fusion of the radio-carpal, intercarpal and metacarpal joints of the wrist by means of a curved graft from the inner surface of the wing of the ilium. The graft is fan shaped, and its natural curve permitted fixation of the wrist in the optimum position of ten degrees of dorsiflexion; it was applied to a deep bed cut in the radius, carpus and second to fifth metacarpals. The operation is suitable for osteoarthritis; infective, tuberculous and rheumatoid arthritis; infantile spastic and traumatic paralysis and congenital deformities. The advantages are the more rapid union than with tibial grafts, and the more certain union than with iliac chip grafts. Thirty patients, two with tuberculosis of the wrist, were successfully arthrodesed, one necessitating a second operation by reason of fracture of the graft.

Bazliel (48) modifies the Brittain wrist arthrodesis by cutting an angled graft from the antero-medial aspect of the tibia with an angle of 140° between the connecting arms. In this way when the graft is incorporated in situ the position of function of the wrist can be achieved without difficulty and the graft is "imbedded" in place throughout its entire length.

According to Bunnell and Howard (49) a Kirschner wire drilled through the ulna and radius just above the wrist effectively prevents all pronation and supination. Incorporating the wire in a forearm cast eliminates the customary long arm cast for preventing pronation and supination.

May (50) discusses the consequences of improper immobilization of the hand, leading to contractures after injuries, infections and burns. He outlines the repair work of these contractures and also the treatment, by surgery, of Dupuytren's contractures of the palmar aponeurosis after the method of Lexer (51).

Despite the frequency of congenital syndactyly and the many repairs devised, after many of the operations in common use either the web creeps distalwards or the range of extension of the affected fingers is defective. Oldfield (52) feels that secondary deformities are due to scar lines which are allowed to develop along the base of the web. Therefore, it would seem that an operation planned with the view of lining the whole base of the web with a single flap of mobile skin would be the operation of choice. Such an operation is described with a single 'U' flap or 'horseshoe' being raised dorsally to fill the base of the web. Lateral digital flaps from the remaining skin are fashioned so as to cover the side of the more important finger (usually the index) and the resulting defects on the other fingers are covered with split thickness skin grafts. The author feels that 2 years is the ideal age for operation but that each case must be individualized. He cautions against operation in adults who have adjusted finger function to the webbing.

Douglas (53) describes an operation to aid in formation of new nail beds. It consists essentially of making a double pedicle flap and shifting

it from the distal end of the finger involved proximally over an artificial nail collodionized to the nail bed. He used the procedure successfully in one case. The pedicle was excised after the new growing nail reaches well out of the finger tip (approximately 5 weeks). He deduces that the procedure may be applied to the problem of split nails.

Armstrong (54) gives details of a technique for arthroplasty used in soldiers with ankylosis of the elbow due to shell wounds. Through two longitudinal incisions, one on each side of the triceps tendon, the head and neck of the radius were removed and the humeral and ulnar elements of the ankylosed joint freed. Sufficient bone was removed from the humerus to make the surface flush with the flat area just above the condyles; the concave surface of the ulna was enlarged with a gouge, care being taken to preserve the insertions of the brachialis and triceps. The sac of a hydrocoele was drawn like a cap over the lower end of the humerus. Graduated movements were begun fourteen days after operation. Mr. Armstrong was impressed with the stability of the new joint thus constructed, as compared with that of other techniques; 60 percent of normal flexion, extension and rotation were regained without pain.

Willner (55) describes an operation through two incisions, one on the medial aspect and one on the lateral aspect of the elbow to release a fibrotic anterior capsule of the elbow affecting a flexion contracture. It is to be understood, however, that all flexion contractures of the elbow are not necessarily caused by anterior capsular pathology. Ten case reports are included with an increase in range of elbow motion from 30-45 degrees (ten degrees of flexion and twenty-five degrees of extension). Post operatively the compression dressing is not disturbed for three days and active exercises started on the fourth day. Forceful extension by weight or trapeze are forbidden. Follow ups have been of short duration.

Rank and Wakefield (56) present a method for elongation of the thumb where the metacarpal is functioning. The procedure is of four stages: 1. The raising of the tube pedicle. 2. Attachment of the pedicle to the hand. 3. Detachment of the pedicle from the abdomen and 4. The bone graft. The tribulations of each step are presented as are 18 case reports in a tabulated table form. Appropriate pictures are included, plus a mention of lengthening of digits other than the thumb, to facilitate opposition.

Schroder (57) discusses the various tendons available for transplantation for the various nerve palsies of the forearm and hand in accordance with the principles propounded by Bunnell. The remedial treatment following surgery and the advantages of various types of occupational therapy in addition to physical therapy are discussed.

Gervis (58) briefly discusses the etiology of simple osteoarthritis of the trapezio-metacarpal joint and describes the not unusual physical findings of the lesion. He discusses excision of the trapezium in thirteen patients and although it leaves the function of the thumb slightly weaker than normal, a full range of motion is regained. Supervised physiotherapy is essential, since due to pain, the patients subconsciously tend to splint the joint. He prefers this procedure to arthrodesis.

Miscellaneous

Although not previously unrecognized, cyst like lesions of the carpal bones have received little attention in the literature. Rodholm and Phemister (59) point out the resemblance of the cyst like areas in the carpal bones to the cysts of the capital femoral epiphysis and have assumed that their pathogenesis is essentially the same. Such lesions are not unlike those seen in the hip in degenerative arthritis. Aseptic necrosis of one or a part of a carpal bone has been described in association with such lesions. These changes are said to be not uncommon.

Nygaard (60) summarizes "a report of a patient who exhibited a non-united fracture of the carpal navicular bone of twenty-two years duration, associated with intermittent Raynaud's phenomenon of the corresponding hand. Functional restoration of the hand followed operative removal of the projecting movable fragment". Preoperatively, the Raynaud's phenomenon could be reproduced by weight carrying but not by exposure to cold. Similarly it could be prevented by local infiltration of novocaine around the loose fragment.

Vaughan-Jackson (61) presents two case reports of rupture of the extensor tendons of the fingers by attrition at an arthritic inferior radio-ulnar joint. At operation the mechanism could apparently be reproduced. When the forearm was pronated and supinated an arthritic roughening of the articular margin of the lower end of the ulna could be seen moving to and fro in a hole in the groove for the tendons and thru which the arthritic lipping could project to impinge on the tendons themselves. Treatment consisted of excision of the distal three centimeters of the ulna and tendon grafting, using 'split tendon' grafts, with almost complete return of function and no residual disability.

Lahz (62) states that tennis elbow can be due to direct trauma as well as indirect muscular violence and that the muscle origins mainly concerned are the extensor carpi radialis brevis, the extensor digitorum communis, and the supinator muscle. The theory of an incomplete muscle tear is unsupported by histological evidence. He believed that the cause of the pain is a localized synovial reaction. The acute stage often passes to chronic synovial inflammation with secondary involvement of the capsule, muscle, and rarely periosteum. In the acute stage plaster fixation is advisable with the elbow flexed and the wrist dorsiflexed. Manipulation is worth trying in chronic cases but operation offers an almost certain cure. The origins of the extensor carpi radialis brevis and the finger extensors should be divided obliquely and the radio-capitular joint explored for thickened synovial fringes.

Schulenburg (63) describes the normal movements of the thumb and the effects of procaine block on the thenar muscle. He reviews some of the literature pertinent to anomalous nerve supply and offers convincing evidence that the flexor pollicis brevis is frequently supplied by the ulnar nerve. Stress is laid on the correct interpretation of movements of the thumb in assessing a case of nerve injury.

Goulding (64) presents a case report of a 22 year old engineer who underwent two exploratory operations for a painful swelling just proximal to the

wrist joint on the volar aspect. Five years later pain and swelling returned and reoperation revealed the muscle belly of the palmaris longus to be grossly hypertrophied, reaching almost to its insertion. The major portion of the muscle was excised. No follow up report was made. A general discussion of the anatomical variabilities was presented with the conclusion that the degree of development attained is in accordance with function. Similarly it was considered that the muscle is gradually passing into phylogenetic decrepitude in man.

Cliffton (65) reports several cases with residual function of the intrinsic hand muscles despite confirmed complete severance of their nerve supply. Communications between the median and ulnar, and median and musculocutaneous nerves via anatomic pathways are described. Granted such cases are unusual, they are of importance in evaluating peripheral nerve injury pre and post operatively.

Bateman (66) presents a method of denervating the elbow joint, based on a study of the innervation of 152 elbow joints from the median, radial, ulnar and musculocutaneous nerves. The technique, stressing extensive stripping of the various nerve trunks through three incisions about the joint, is described. Summaries of eleven cases are included. In those with post traumatic and osteoarthritis, there was relief of pain and painless, but not increased, motion. One patient with acute rheumatoid arthritis redeveloped pain after six months. The longest follow up period was 21 months. No complications were noted.

Doyle (67) gives case presentations of some of the more common types of syndromes in which radicular pain in the upper extremity is a predominating feature. The author summarizes: "radicular pain in the upper limb has the same general characteristics it exhibits elsewhere. It is limited to the area of distribution of a sensory nerve root, is generally aggravated by coughing and straining, and by reclining for long periods, and is frequently relieved by assuming the upright position. If severe or persistent it may be accompanied by muscular weakness with atrophy and fibrillations due to degeneration of the fibers of the corresponding motor root."

Haggert and Winter (68) discuss the anatomy, pathology, clinical course and treatment of DeQuervain's disease. They recommend operative treatment and condemn radiation therapy because the latter fails to give relief and results in fibrosis and scarring, making the surgery more difficult. Postoperatively, active thumb exercises are commenced after 24 hours.

In a discussion of Dupuytren's contracture, Gordon (69) concludes: "Dupuytren's contracture is a fairly common lesion of the hands and is occasionally seen in the feet. Its etiology is unknown: its pathology questionable. It is commonest in males, and develops most frequently between the ages of 40 and 60. When first seen clinically, both hands are involved in a majority of instances; if only one hand is involved, it is usually the right. Finger involvement occurs in the 4th, 5th, 3rd and 2nd and thumb, in that order, the 4th being involved ten times more frequently than the 2nd. The only satisfactory treatment is the excision of the palmar fascia, together with any hopelessly involved skin. Skin replacement can be done satisfactorily with a thick dermatome graft. A good result may be expected in 85% of the cases." These conclusions are based on experiences with 100 cases of the condition plus a review of the literature.

Hammond and Dotter (70) present a case of Dupuytren's contracture of the palms of both hands and soles of both feet. The left hand was operated and revealed the characteristic connective tissue hyperplasia without evidence of inflammatory reaction. They state they believe the incidence of the condition in the feet would probably be much greater if examination were carried out on those patients presenting themselves with the hand involved. Specimens were not procured from the feet of the patient presented.

Fauteux and Ripstein (71) state that the etiological relationship between Dupuytren's contracture and coronary heart disease is not established but the possibility of the contracture being due to irritation of the sympathetic nervous system must be considered. Two cases of the contracture are presented which followed coronary occlusion.

Stecher and Hauser (72) present a study of the gross and roentgenographic appearance of Heberden's nodes because they are typical examples of degenerative joint disease. They emphasize the value of photographs and lateral roentgenograms in describing and following the progress of these lesions. The development of large spurs at the attachments of the flexor and extensor tendons to the terminal phalanges and the "foamy arrangement of the trabeculae" in the distal ends of the middle phalanges are characteristic. Heberden's nodes were associated with degenerative joint disease of the proximal interphalangeal joints in 40% of their cases. They conclude that degenerative joint disease involves periarticular soft tissue, tendinous attachments and subchondral joint spaces as well as the joint cartilage and the immediately underlying bone.

Newman (73) describes the anatomy of the carpal tunnel, emphasizing the fact that it is a closed space of bone covered with a roof made up of the transverse carpal ligament. He conjectures that the nerve is involved first during diminution of this space because the nerve lacks the protective coat of the tendons, namely, their tendon sheaths. The effect of pressure is one of ischemia rather than direct irritation. Three 'types' are presented: 1. Due to acute trauma. 2. slow compression with spontaneous onset, and 3. slow compression secondary to malunion or arthritis. The symptoms and signs are outlined. He presents three cases, each treated by incision of the transverse carpal ligament with complete relief.

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SECTION 18

AMPUTATIONS AND PROSTHESES

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Amputations

Charnley (1), in discussing amputation for the benefit of the general practitioner, presented the principles which govern the diagnosis of the ideal stump; the principles underlying the technique of emergency amputations, and the domiciliary supervision of the recent stump.

The Design of the Ideal Stump: In the arm and forearm preservation of maximum length is of paramount importance. The author is against the old dictum contraindicating amputation through the proximal interphalangeal joints, as many fingers so amputated have had powerful flexion afterwards. In the case of an index finger, a careful amputation through the shaft of the metacarpal gives a good cosmetic result. In the lower extremity, only two stumps are recognized as ideal; below knee amputations containing four to five inches of tibia, and above knee amputations contained from nine to twelve inches of femur. It is recommended that the bone end be covered only with skin and deep fascia; that the nerves be sectioned at the level of the muscles and that they are not drawn down, crushed, injected with alcohol, or tied with ligatures. Though these principles are those which underlie the present teaching in the amputation of election, it must not be forgotten that there are many unorthodox amputations still functioning or which have functioned well for years. A Syme's amputation is preferable on a young man rather than an immediate below knee amputation, although suitable cases are rare. (Ed. note: It is believed that more cases can be found suitable for Syme's amputation particularly if done in two stages for infected foot and ankle wounds.) Many patients have been seen with an amputation through the forefoot (Lisfranc) who are able to walk well in an ordinary shoe, after filling the toe with cork. Between the Syme's and Lisfranc's, however, nothing should be attempted; experience has shown that the Chopart's amputation is not a good amputation.

Two Primary Objects in Emergency Amputation: One is to aim for the longest possible primary stump, and two is to plan the amputation with flaps for delayed closure. A guillotine operation should never be performed by sectioning the bone and soft parts at the same level, because healing is slow, the patient is miserable, and elective amputation will generally have to be risked in the presence of an unhealed terminal ulcer. In aiming for a generous length of primary stump, the bone should always be divided at a higher level than the skin in order that flaps can be fashioned of sufficient length to cover the bone end. In all emergency amputations the wound should be regarded as more or less heavily inoculated with bacteria. Delayed closure of the amputation stump with the use of dry gauze packs, which are removed under aseptic precautions not later than the fifth postoperative day, gives a good result in the author's hands.

Care of the Stump: While awaiting the fitting of a stump two objectives must be attained; one the shrinkage of the stump into a conical shape, and two, the prevention of flexion contracture in the joint proximal to the amputation. The conical stump is achieved by careful bandaging which is done by the patient or a relative who has been properly instructed how to reapply the bandage morning and evening. The flexion contracture of the joint proximal to the level of amputation can be prevented by regular exercises to strengthen the muscles. In finger amputations the use of other digits is of great importance. Bandages must be discarded as soon as possible to expose the stump to the air, and to permit the use of the fingers actively.

Illingworth (2) reviews the subject of amputations, listing indications, and gives a good discussion of the technique used for each site. The description of prostheses is brief.

Blair and Morris (3) in a study of 2,612 patients with 2,767 major amputations give a resumé of technique, preferred levels, precautions and prostheses as used on an orthopaedic service at one of the Army's amputation centers.

Swenson and Bisgard (4) discuss various levels of amputation and the most suitable prosthesis for each. They deplore the lack of coordination between the surgeon, physiotherapist and limb fitter.

Maxeiner (5) reports the results of the use of tourniquet amputation in 20 cases. He suggests its use as an expedient to be used in those cases in which an extremity must be sacrificed but in which a classical amputation would be extremely hazardous. The tourniquet may be used for a few days only at which time a classical operation may be done if the improvement in the patient's physical state warrants, or it may be allowed to remain on until a guillotine amputation has been accomplished except for the insensitive compressed tissue and bone. The author gives as indications for the life-saving procedure as follows: (1) Severe trauma with irreparable damage to an extremity of a patient who is suffering severe shock from loss of blood or the magnitudes of his injury; (2) Virulent infections, especially gas gangrene; (3) Gangrene due to disease, or concomitant diabetes or concomitant critical heart disease. The rubber tubing is tightly stretched and wrapped about the selected site, each turn of the tubing overlaps the one below so that the constricted area is as narrow as possible. The extremity distal to the tourniquet is next wrapped with a goodly quantity of white cotton, saturated with formaldehyde solution and enclosed in a rubber sheet. In 8 to 10 days a groove through all the soft tissue to the bone is made, at which time a Gigli wire saw may be placed in this groove immediately above the tourniquet and the remaining tissue and bone cut across without anesthesia. The author's report of statistics on the 20 cases showed that there were 6 deaths or a mortality of 30%, none of which could be attributed to the method.

Altavas (6) reports a case of auto-amputation of the thigh in a case of gangrene, following a compound fracture of the femur. Healing was completed by secondary intention and no surgery.

Allredge (7) presented an excellent report on cineplastic amputations with additional knowledge of the cineplastic method gained from

observations by the Army Surgeon General's European Commission on Amputations and Prostheses in 1946, and the work of the Committee on Artificial Limbs since that time. In Germany the cineplastic method still in use is that of Sauerbruch, developed during and after World War I. The method was found to be in active use in two centers, Munich and Berlin. In these centers cineplastic methods were not used to the exclusion of other methods. Patients were usually given their choice of the three methods generally used - the cineplastic, the Krukenberg, and the conventional methods requiring no surgical procedures.

Sauerbruch in Berlin has continued to use the conventional cineplastic method. Lebsche of Munich has introduced a modification which seems to improve the results without unduly complicating the procedure. He introduced the practice of liberating the distal attachments of the canalized muscle in cineplastic operations. It was the author's observation that this produced more excursion and strength of the muscle, and was better controlled by the patient.

"The principle of the method consists in the use of two muscle motors on the arm; these are constructed by raising a flap of skin on the stump and converting it into a tube, which is placed through a hole in the muscle belly. When the muscle is contracted by the amputee, the tube is moved. A rod through the tube is connected to the prosthesis. Active contraction of the muscle thus governs the action of the prosthesis through the rod. One muscle motor is constructed on the flexor surface of the arm and the other on the extensor surface. The selection of the sites for placement of the muscle motors is of the utmost importance. The muscles should be tunneled at the distal end of the muscle fibers. The excursion of the muscle tunnel is in direct proportion to the width or diameter of the muscle belly. The biceps alone or the biceps and triceps should both be canalized for short stumps below the elbow, and the pectoral motor should be used for short arm stumps above the elbow. The preoperative and postoperative care, consisting chiefly in proper muscle exercise, is highly important. Before operation, all of the muscles are strengthened to the maximum extent, and the patient is taught selective use of those to be tunneled. Following operation, the patient is taught active use of the muscle motors, while the muscles are stretched to their full length. Strength and excursion of the motors are increased by active contraction of the muscle motor against gradually increasing resistance on a rod which passes through the tunnel."

The author found the German cineplastic prosthesis was essentially the same as that originally developed. It lacked many desirable cosmetic, functional, and mechanical features. It is also very delicate, and the component parts are subject to wear and frequent breakage. When a better prosthesis has been made available, the method may well enjoy more extended use than at present. The results of studies on this subject at the University of California have indicated a definite need for compensatory mechanisms in the prosthesis, to take the place of the natural one which were lost when amputation was sustained.

(Ed. note: Prostheses are now available to make the biceps tunnel an excellent motor for the below elbow amputees. Flexor and extensor

tunnels are not necessary and in the forearm are not proving to be of too much use. The pectoral tunnel is excellent but still needs some study to apply its power adequately.)

Craft (8) discusses Krukenberg and cineplastic operations. He favors the Krukenberg operation because of the retention of tactile sensation but did not like its appearance. In his discussion of the cineplastic motors he felt that the main drawback was the fitting with proper prostheses. He discussed the advantages of relieving the distal end of the truncated muscles and a large diameter tunnel.

Millar (9) gives a case report of a traumatic forequarter amputation which was closed primarily after shock therapy and had healing in 14 days.

Vasko (10) gives a case report on an almost complete subcutaneous traumatic amputation of thigh which was saved by adequate surgery on bone and muscle. (Ed. note: With retention of adequate blood supply and soft parts for coverage transversely severed muscles should respond to repair.)

Wise (11) devised a method of control of the common iliac artery in sacro-iliac disarticulation. Early in the operation he places a tape through a section of soft rubber tubing, clamping the tube with a hemostat. After all branches are ligated, the tape is removed.

Van Nes (12) reports the replacement of a totally resected femur with a "turn-up plasty" of the leg to replace the femur with tibia and fibula. The patella is left at the end to bear the weight as in a Gritti-Stokes amputation.

Phantom Limbs

Browder and Gallagher (13) studied 150 amputees for all types of conditions. All adults had some degree of phantom limb for a variable period; 33% suffer with pain either in the stump or phantom limb, 75% of these slowly lose it. No phantom limb was noted in the congenital absence of a limb. The lower extremity amputee has less striking phantom sensation and is most likely to lose it spontaneously. In cases when the "ghost" was distorted or cramped there was intractable pain for which the authors advocate cordotomy. They have improved 6 cases with the operation.

Bingham (14) (15) feels that sympathectomy is treatment of choice following the use of procaine blocks to evaluate its efficacy. He does not believe that character of sensation is any differential point as to cause or treatment.

Craig (16) uses a local injection of 1% novocaine into the sympathetic nerve supply repeating it indefinitely and believes the remission will eventually become sufficiently long to avoid more extensive surgery.

Carlton (17) believes the blocking of afferent impulses at the level of the thalamus causes overreaction resulting in phantom pain. He feels overstimulation of the stump will overcome this and advocates firm manipulation, beating of stump with hand and mallet.

Prostheses

Brashear (18) by questionnaire tried to evaluate the value of artificial appliances in upper arm prostheses. He received answers from 55 who used them. Only a shoulder disarticulation case did not use one. The average cost was \$300 to \$350.

Henschke and Mauch (19) describe an improved leg prosthesis with control of knee by voluntary and involuntary fixation to prevent falling with abdominal muscle control of a hydraulic-mechanical system. The ankle allows movements in pronation and supination also. (Ed. note: This has been further improved to provide the control within the leg itself.)

Kessler (20) discusses a utility attachment for cineplastic artificial arms, to provide prehension without crushing objects.

Strickland (21) describes a pneumatic artificial foot; Fahlstrom (22) and Markkula (23), a knee joint; Eberle and Hansen (24), a hydraulically operated limb; Snethan (25), an artificial hand and arm; Hinkle and Weger (26), a knee lock for artificial legs; Havens (27), a linkage for artificial legs and Tureman (28), an artificial hand.

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SECTION 19

NEW DEVICES, APPARATUS AND PROCEDURES

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Introduction

As in past years, literature covering new procedures and appliances developed and reported during the year 1948 contains a number of ideas and gadgets which are usually modifications of previously used methods with their inventors' or authors' recommendations for use because of containing some allegedly improved technique which produces better results or which simplifies methods already in use. At times some of the recommended developments appear to complicate already established procedures, and only time and repeated application of the new principles recommended will establish their general value to the orthopedic and surgical profession.

Devices

A new dermatome was patented in 1948 by Hood (1) and the specifications and illustrations indicate that this dermatome is a modification of the Padgett dermatome. The author claims that this dermatome provides greater visibility during the operation and simple, easily manipulated parts, reducing the necessity of making adjustments excepting to set to the thickness of the graft desired. Further, he states that this instrument involves elements for maintaining the severing edge of the cutting blade in a given position. The specific objects of this new dermatome comprise a provision of normal, unique and positive blade-holding structure which prevents the sharpened edge of the blade from ever coming into contact with the surface of the graft holder.

Wydro (2) has patented a dentist's and surgeon's saw particularly for use in the mouth which can be attached to an ordinary dental power machine. The inventor claims this saw to be a definite improvement in removing teeth and operating upon the jawbone or in similar cramped spaces. It consists of the principle of having two reciprocating blades so arranged that the cutting action is continuous and is always in a position for cutting.

(Ed. note: This saw is simple and compact in construction and can be attached to a modern dental power device.)

Carroll (3) developed a bone cutting saw for larger bones which utilizes the principle of an oscillating saw blade, which is adjustable for

right angle, oblique and longitudinal cuts, and has the advantage of steadying the object to be operated upon by featuring a saw guard having spaced arms adapted partially to embrace and steady the bone. This new saw includes another feature which allows the blade to yield to the embraced bone. The blade of the saw is driven by a flexible cable which is connected to a crank disc, which in turn is operated by a prime mover.

(Ed. note: The saw is small and easily maneuverable, is held by pistol grip and does not contain the power unit in the saw assembly head.)

Gunther and Keyes (4) report a simplified depth gauge for bone surgery. It is similar to the one in common use except for the set screw, which is always awkward. A curved spring slide without set screw is used and there is a ring in the end of the wire instead of a heavy handle.

For two years Curry (5) has used a hip nail counterbore with diameter of the Smith-Petersen nail. This opens the dense cortex of the femur to allow the nail to enter without fracturing the sometimes already comminuted bone. This device was used in 50 cases.

Herz, Breck and Basom (6) have designed another type of lock screw for securing an intertrochanteric plate to a Smith-Petersen nail. The modification described, combined with the lock screw, places greater emphasis on security and, the authors further state, "without adding to the difficulty of application". Essentially, the improvement consists of the use of a left-handed small screw inserted into the 1/4" - 20 screw already in use by many surgeons. This develops a locking mechanism for the plate so attached to the nail and thereby overcomes a possible complication of separation of nail and plate after its use.

A new laminectomy retractor is described by Reed and Kirgis (7) which is of simple construction, consisting of a brass frame which accepts retractor blades of varying depth as required by the thickness of the paravertebral musculature. The device is made self-retaining by a spring-steel locking device which prevents closure of the telescoping sides of the frame. The solid bars of the frame have 5 holes reamed to allow that number of insertions of the retractor blades, so that they may be applied at the points where greatest retraction is needed. The device is equally useful for unilateral or bilateral exposure.

Two semilunar cartilage knives are presented by Downing (8) as an aid in removing these structures. The description of the knives, one curved to remove the posterior half of the attachment of the menisci to the tibia and synovia and the other a straight, long-handled knife with a strong blade to sever the posterior attachment with or without displacement into the intercondylar notch, appear to be an improvement over some knives already devised.

Stein (9) describes a tungsten steel gouge for use in a Nicola operation. This improved gouge, he feels, materially helps in drilling the hole from below the bicipital groove to the center of the head of the humerus. The gouge is similar to the one used by Nicola except that it has a serrated opening or eye, proximal to its point, which is made by making multiple drill holes adjacent to each other and tapering in their diameter

toward the point. As the hole is completed the point of the gouge goes into the acromium above, and the proximal end of the cut biceps tendon is threaded through the new hole in the humerus and the gouge withdrawn. The eye of the gouge is thick to prevent cutting of the tendon and tapers toward the point better to engage the tendinous tissue, insuring security as the gouge is withdrawn. The gouge measures $1/4$ " in diameter.

Another "well-leg" type of traction apparatus was developed by Henderson (10), primarily providing an improved traction splint, using the sound leg as an anchor, embodying a comfortable construction device for the well leg, and allowing limited movement of the well leg. By means of a bone pin through the lower tibia, or os calcis, traction is applied to the injured lower extremity in an adjustable manner by two crossjack bars. The author claims increased maneuverability by the application and use of this method of traction, as compared to the use of plaster casts. The author claims advantage over the present methods of well-leg traction due to absence of plaster cast and ability to bathe and cleanse the injured part.

The Roger Anderson Well-Leg and Well-Hip Traction devices, designed and first reported in 1931, are described in detail by Miller (11).

Raney and Raney (12) report a minor modification of the Crutchfield tongs by adding a flange sleeve to rest against the outer cortex of the skull and also to increase the size and reduce the sharpness of the point, as compared to the standard tong.

(Ed. note: The advantages claimed seem quite justified and should aid in eliminating the occasional complications seen in the use of the standard Crutchfield tong for head traction over a prolonged period of time.)

Fulcher (13) reviews the various types of apparatus which have been introduced to apply skeletal traction to the cervical spine. He recommends an improvement over the Crutchfield tongs. The apparatus, briefly, consists of a 7" wide duraluminum horseshoe frame, which is shaped like a traction bow and fits well over the patient's head. To this frame stainless steel pins with blunt ends are attached after their insertion into the cranium 3 cm above and 1 cm posterior to the pinna of the ear. The insertion of these pins is done under local anesthetic without incising the scalp and there are necessary safeguards and protective plates which are used to prevent injury to the cranial content. The pins are inserted into the parietal portion of the cranium at right angles. He has used this apparatus on 26 patients and has found that it is comfortable; that it can withstand greater traction force than previous apparatus of a like nature which he has used and that no adjusting is necessary while the apparatus is kept in situ. He believes that this apparatus fulfills the criteria sought better than previously used similar tongs.

Pincock and Pava (14) have devised an appliance for inserting one or more Kirchner wires or metallic pins through bone, particularly in the treatment of a fractured mandible or other jaw bones. This device aids in applying a wire across the fracture, then allowing the removal of the

device. The ends of the Kirchner wire are buried beneath the skin until ready for removal. With this device, it is felt that oral hygiene and normal mouth functions are more readily maintained than with other appliances now in use.

Eggers (15) has demonstrated that fracture ends of bone fragments show variable absorption of the surfaces, both clinically and microscopically. Even in the most accurate reduction, the usual commercial plate actually results in holding the bone surfaces apart, producing delayed or non-union. Therefore he designed the contact splint, which is a slotted type of plate held in place by the necessary screws, which are not inserted to a point of tightness to produce binding of the splint to the bone. The screws are applied as far from the fracture line as possible. The resulting muscle pull produces constant and continuing apposition of the fractured surfaces.

(Ed. note: The advantages and physiological correctness are discussed in simple and convincing detail in this article and it is felt that this new device is a definite forward step in both the understanding of bone healing and strengthening of the armamentarium now in use for the internal fixation of fractures. The mechanical forces producing locking at the fracture site, even though the contact splint is not applied tightly to the cortex of the bone, are well described in this article.)

Zuelzer (16) reports on an indirect method of fixation of small fracture fragments with the help of a hook plate. A single Lane plate can be used on such small fracture fragments and fractures such as the medial malleolus, olecranon, tibial plateau, where periosteal suturing or wiring will not suffice. Hook-plate fixation can be used away from the joints and in cortical bone. Damage to joint is avoided and small fragments are not split by screws. Circulation and joint surface is not impaired. This is indirect fixation.

(Ed. note: We have used a similar principle about the malleoli, with a small hook-plate prepared from ordinary Lane plate by cutting out the end screw holes and find it a very suitable method.)

Results of recent studies and experiments concerning metals used in the internal fixation of fractures are reported by Stuck and Venable (17). No single standardized metal has been decided upon as proper for use in internal fixation. Vitallium plates and screws are definitely more inert than the various alloys of stainless steels so far studied and used. Stainless steel alloy, so-called "18-8 SMO", is the best alloy so far obtained and has the advantage of strength and uniformity. However, it has not proven as inert as vitallium in vivo. Therefore, the surgeon is left with the choice of either 18-8-SMO or vitallium. Neither type of metal should be combined in a single operation.

According to Herschell and Scales (18), plastic splints and appliances must have the following desirable properties: durability; ease of manipulation; cheapness; light weight; radiolucency; transparency; inertness and freedom from irritants. All of the usual splints and casts may now be made of plastics with little equipment in many cases.

Littler and Tobin (19) describe a thumb abduction splint made of an arc of brass or steel set in a forearm cuff. This splint allows thumb abduction with counterpressure on the second metacarpal so that radial deviation of the hand does not occur.

Wheat (20) uses an apparatus for maintaining rotation of the lower extremity while in traction. The author states that Russell's traction, which is commonly used for fractures of the neck or trochanter of the femur, has the disadvantage of skin traction and of not holding the limb in proper internal rotation until healing occurs. To prevent these difficulties, the author has employed this routine: Sodium pentothal anesthesia; Kirschner wire through the lower tibia; a well padded plaster boot with the dorsum of the foot and ankle cut out for active motion. Apparatus applied to Kirschner wire and traction applied to cast. Apparatus consists of two tubes, 26" long, held by movable crosspieces at each end to adjust the width. These tubes are slotted to allow motion of the upright assembly in a longitudinal plane. The uprights are joined at their bases to a freely movable crosspiece, to which is fixed a small foot plate. The uprights are furnished with adjustable fixtures with apertures which loosely hold the Kirschner wire. Up-and-down adjustment of the fixtures provides the desired degree of rotation.

Imrie (21) describes the control of the position of the lower extremity by an elastic bandage. When a lower extremity assumes an unnatural position, usually external rotation and hip flexion, as in the muscle imbalance seen in some poliomyelitis cases, the extremity can be easily returned to a neutral position by use of an elastic bandage single hip spica placed over padding.

Terhune (22) reports on an apparatus for correction of flexion deformity of the knee, which he has used successfully on the principle described by Horwitz. Turnbuckles are replaced by rubber bands. Most important advantage is that the patient can constantly exercise the muscles and the knee joint. Pressure ulcers frequently seen in turnbuckle casts are much less frequent in rubber band traction.

Urist, Ries and Quigley (23) describe a plaster traction splint for compound comminuted fractures of the tibia and fibula. This was used in 65 battle-incurred injuries of these bones and 11 other simple and compound comminuted fractures. A traction splint, made of materials in the usual supply, consists of a plaster cylinder padded with felt in the upper thigh, popliteal, and malleolar regions, and is applied from the groin to the ankle while the knee and hip are flexed at 45°. "U" shaped wire loops of #12 iron wire or similar metal rod are incorporated in the cast at mid-thigh and malleolar levels. A heavier or two similar wire loops are incorporated at the knee. A Pearson attachment, with a pulley fastened to the crossbar, is placed over the leg in sagittal plane and attached to the hoop at the knee. The ends of the wire at the malleolar level are wound around the Pearson attachment. The anterior portion of the cast is cut out from the superior pole of the patella to the ankle. The leg is suspended in a Balkan frame. The foot is supported by stockinette or moleskin sling. Patient can be placed in a wheelchair with this traction after acute painful period is over.

The results of clinical tests with Aire-Lite, a glass plastic material used as a substitute for plaster of paris, is reported by Russell, Bateson and Loos (24). They claim this material has the following advantages:

1. Extremely light, strong and resilient. 2. Unaffected by water or usual solutions. 3. Waterproof to scrubbing. 4. Non-irritating to skin. 5. Transparent to x-rays, obviating removal of fixation for later progress films when not necessary. 6. Non-toxic. 7. Can be autoclaved. 8. Easily cut by plaster cutters. 9. One bandage equal to several layers of plaster of paris. 10. Readily conforms to all bodily contours. 11. Can be applied skintight or over padding. 12. Non-cohesive to other materials. 13. Subsequent reinforcements readily fuse to original cast. 14. Fluid available for softening cast to remove with scissors. 15. Elastic when applied.

Padded versus skin-tight Unna's boot and similar types of leg bandage is discussed by Orbach (25), who urges all practitioners to adopt his padded Unna Paste Boot, which consists of the following layers in this order: 1. A layer of zinc paste direct to the skin. 2. A single layer of dry wide-mesh 3" gauze bandage. 3. A single layer of sheet wadding. 4. A 4" wide mesh gauze bandage, saturated with zinc-gelatin mixture. This layer must then be painted (reinforced with warm liquified zinc-gelatin mixture). From Orbach's experience the Unna Paste Boot, applied directly to the skin, has caused phlebitic and necrotic ulcers; therefore he believes his modification to be an advantage.

Boone (26) recommends a rocker type of walker for fractures below the knee. His device is made of pine or aluminum, with a rubber sole, attached to steel uprights and triangular side pieces. This brings the apex of the convexity of the walking surface in the weight-bearing line and allows a normal walking motion.

(Ed. note: We have used a similar type of walker of simple wood construction and rubber sole without uprights and are convinced that the patients are more comfortable in walking with this than the single U-shaped type of caliper in common use.)

In the quest for an improved walker for casts, Thompson and Plewes (27) have designed a wood-soled boot to be worn on the foot of the cast as one would wear a shoe on an uncovered foot. A sorbo rubber instep provides springiness; leather straps provide support and enable the patient to remove the boot when sleeping, thus preventing soiling of the linen, and the boot itself presents a smart appearance. The boot weighs 1.5 pounds.

(Ed. note: Although the authors claim normal heel and toe motion is possible, it would seem that the wooden sole precludes such.)

Knudson (28) reviews the progress of Physical Medicine pointing out the importance of good braces for the thousands of paraplegics and potential users of braces cared for by the Veterans Administration Facility. No new brace device or development was mentioned. The importance of the brace maker to the patient was stressed, as well as the magnitude of the jobbing performed by the Veterans Administration.

Orthopedic appliances in the rehabilitation of patients with spinal cord injuries are discussed by Bickers (29).

(Ed. note: It is believed that all orthopedic surgeons and neurosurgeons engaged in treating paraplegics or patients with spinal cord pathology should review this article from the standpoint of fitting braces.)

Approaching the problem of fitting walking caliper braces to those patients needing ischial support, Howard (30) stresses simplicity and deplors variation in the caliper ring. He introduces a ring which he has found suitable for all except the very fat types of patients. This ring is ovoid in shape with an indentation at the postero-medial section and a sharp drop just posterior to the medial side member. It is essential that the slope of the posterior section of the ring terminates midway between the medial and lateral side members and from this point to the indented section the ring must be perfectly horizontal to prevent the tuber ischii gravitating to the perineal section of the ring, which causes an internal rotation of the limb in walking. He prefers a wide 4" to 5" anterior soft leather tray (cuff) to prevent the tuber ischii slipping forward. This cuff should be tightly adjustable with straps and buckles. The only other supports then become a knee cap and a calf cuff.

A device in which springs replace the action of paralyzed muscles of the arm is described in detail by Ward, Bohlman and Wood (31). A brachial plexus type of palsy, with loss of abduction, external rotation at the shoulders, loss of flexion at the elbow and some degree of weakness of wrist extension occurred in one of the authors as the result of a spinal cord tumor. This prosthesis is described in detail and consists of antagonist springs which were substituted for the affected muscles and which were very accurately gauged to produce a floating mechanism of the shoulder, elbow and wrist joint functions. The author, a surgeon, was able to return to a daily normal routine of gardening, driving his car, and resume his active practice of general surgery.

Bailey (32) discusses a rotatory frame for plaster beds. The frame consists of a wooden base with three crossbearers which, instead of supporting a plaster shell direct, are grooved to take three circular discs. Each disc is divided in half and each half shaped to the respective anterior and posterior shells centrally, leaving the circular periphery to rotate on the grooved frame. The author claims the advantage that the nurse can rotate the body cast patients 180° very easily. The disadvantage is that the new discs must be fashioned centrally for each new body cast.

Hipps (33) describes a broad canvas sling, the ends of which are attached to a rope passing through an overhead pulley. With this aid, a patient in a cast may turn himself in bed by pulling the rope on the side to which he wishes to turn.

Allen (34) describes a wedge pillow made of wood in a triangular shape padded on its sloping surfaces. She states that it makes a very satisfactory device for maintaining hyperextension of the spine. This affords rest from the supine position on the Whitman frame without interfering with the essential corrective position. Being made of wood, it offers firm support, more effective than from the use of feather pillows. The base of the wedge is 22" long and 30" wide. The height is 8 1/2" and the

top padded surface 24" long. If additional hyperextension is needed, the wedge may be made higher or it may be used as a firm base on which additional pillows are placed. The size and height of the wedges used can be varied.

Ferguson (35) describes a mobilizer attachment for the Stryker frame. The attachment consists of a child's tricycle wheels and propulsion mechanism, which is used by the patient, developing and keeping his non-paralyzed upper extremities in tone.

Procedures

Caldwell (36) discusses orthopedic problems and prosthetics. Methods in control or elimination of infection of bones and joints; measures to insure and hasten bony union by improved appliances and bone grafts; and production of more comfortable efficient lives for amputees are reviewed. Chronic osteomyelitis, being the result of low-grade mixed infection and poor circulation, should be combated and is improved by physical therapy and then careful surgery. Bone graft technique studies show that cancellous bone is better except for weight bearing, where both cortical and cancellous bone should be used. Stimulation of bone healing with acetyl thyroxin and choline have not produced any results. Studies of metallic plates and alloys have showed that in vitro resistal KA 2 steel was best, with less reaction. The work of the Panel on Amputations of the National Research Council was discussed and its recommendations listed for hooks, elbow joints, plastic hand gloves, ankle joints, lever joints, plastic sockets, etc.

Lowry (37) analyzes 721 war wounds in 360 consecutive cases incurred in World War II and shows not only the important contribution of secondary closure of wounds in reparative surgery but significantly proves that the optimum time for closure is on the 4th or 5th day after injury and/or initial surgery. Delayed closure of wounds should not be forgotten in the postwar era, especially for the management of trauma associated with severe contamination, marked destruction of tissue or prolonged lag between injury and treatment.

Clark and Wolfson (38) report on a series of 130 stellate ganglion blocks using local anesthesia. The authors describe a technique of lateral approach that they feel has the advantage of relative safety, since no vital structures are traversed, as well as ease in changing the direction of the needle, since bony contact is made at a depth of 1 to 3 cm rather than the 5 to 7 cm depth common to other methods. The results of the blocks were not spectacular. Of 130 blocks, only 4 gave relief over ten days; however, in most other cases, the need for narcotics and sedatives was considerably diminished. The types of cases which were so treated included practically all types of painful stumps and upper extremities, for which this type of therapy has been tried.

Breck, Basom and Sims (39) report their method of holding corrective osteotomies of long bones in their proper positions by the use of properly bent 6-hole vitallium plates. They feel that the use of internal fixation

in this manner, in addition to plaster, assures more successful and desirable results and that this method offers a definite advantage over other methods for older children, adolescents and adults. The method is presented to call attention to this valuable adjunct in crippled children's surgery. Three cases are presented, illustrating three different types of osteotomy in which this method was used. A severe genu valgum following knee fusion for tuberculosis, an adduction contracture of the hip following fusion for tuberculosis, and a deformity of the femur following poliomyelitis were treated by osteotomy held by bent plates. The authors do not claim that this is an original or new method but are simply calling attention to this aid.

Scuderi (40) describes a technique for performing the Lorenz osteotomy in cases of ununited fractures of the neck of the femur. In this self-centering Lorenz osteotomy of the neck of the femur, a "V" cutting of the femur is performed just above the superior border of the lesser trochanter. The advantage of this is that the shaft does not then tend to displace anteriorly or posteriorly beneath the stump of the neck, which is the usual cause of failure in using the straight osteotomy.

Hoyt and Baker (41) present 56 cases in which they used interfacet vitallium screws in a Hibbs type of spinal fusion. In these 52 cases, which were followed for one year or more, results were excellent in 22; good in 22; fair in 6 and poor in 2. Their technique consists in using 5/8" to 3/4" screws, which are inserted at 20 to 25° inferiorly and 10 to 15° laterally across the facets. No tibial grafts are used. Additional bone is obtained from the sacrum or ilium when needed.

The so-called "H" type of graft for lumbosacral fusion is reported by Altenberg (42). The technique for the double notch graft is described in detail. The author uses both iliac and tibial bone. The graft is applied while patient is flexed and upon extension of the spine is locked into place. Tibial bone is used for H-graft; iliac bone for the surrounding area. Early ambulation follows and the patient is fitted with a brace two weeks postoperatively and followed for six months. 34 cases were reported with failure of fusion of two cases and functional failure in one, giving a total of 12.5% poor results.

(Ed. note: This type of H-graft has been used from the ilium alone by the reviewer and considered quite satisfactory without the addition of the tibia.)

Gibson and Loadman (43) conclude that the cortical onlay graft fixed with vitallium or stainless steel screws is the most efficient treatment for ununited fractures, or for bridging short defects in the radius, ulna, humerus or femur. This conclusion was reached by analyzing a series of 105 cases in which bone grafting was performed for non-union or bone defects. 93 cases were successful. Cortical onlay grafts gave 79% union; cortical inlay grafts gave 81% union; cancellous bone alone gave 87% union but when combined with a metal plate 69% union occurred.

Henry (44) discusses homografts in orthopedic surgery. He feels that they have a definite place in treatment when a sufficient quantity or quality of bone cannot be obtained from the patient with ease or safety.

During the past 35 years in which homografting has been more or less used, there has been no factual evidence that this is an unsound surgical procedure.

Brown and DeMere (45) discuss the use of homogenous cartilage graft bank. The authors describe the technique for obtaining material at autopsy from the costal cartilage. Preservation is accomplished in merthiolate solution, changed bi-weekly. Sterility is safeguarded by repeated cultures. Cartilage may be preserved for use up to two years. It may be noted that successful preservation and use depends on careful cleaning of the material.

Soderberg (46) stresses the use of open flap skin grafting and of the tube pedicle graft, giving the advantages and limitations of each. He then reports, with illustrations, the use of a combined tube and flap for covering very large defects. This method allows the construction of a flap which will exactly cover the defect and has the advantage of being suitable for intermediate transfer by means of the tube. For example, the wrist may be used as an intermediate carrier in a graft from the abdomen to the lower extremity. Above all, the author stresses the fact that in any of these procedures no attempt at haste should be made. Blood supply is all-important.

Pratt (47) recommends tendon repair with steel wires. He uses very fine steel wire in such cases, following his own experience and observation that silk sutures in the ends of severed tendons which were used as guides for delayed repair frequently caused sinus formation. The use of wire sutures for such guides was followed by its use in both initial and delayed repair. #35 or #36 wire threaded on minute needles are used and the advantage is claimed that there is less peritendinous reaction with scarring and adhesion formation. The technique of use depends greatly on avoidance of kinking of the wire.

Tantalum wire in surgery is presented by Schlaepfer (48). The author presents a new type of tantalum wire which he has used for the past 7 months. The wire, in contrast to the old wire, is braided. It is a superior, non-absorbable, non-scarring, non-reacting suture. He used this in all fields of general surgery but his only application to orthopedics was in tendon and nerve injury. It is excellent for tendons in that it allows much earlier motion without reaction than was previously possible with silk and cotton sutures. The author advocates the use of short-wave diathermy to promote the early healing of wounds. No reactions have occurred when short wave diathermy has been used with braided tantalum wire.

A simplified technique for patellectomy is described by Boyd and Hawkins (49). Through an anteromedial parapatellar incision, the quadriceps expansion is incised longitudinally in the midline, prolonging the incision into the patellar and quadriceps tendons for 1 cm. The patella is then split longitudinally and each half removed by sharp dissection. The extensor apparatus is then closed by imbrication. This method eliminates the tension encountered in methods requiring transverse closure.

Beaded wire in treatment of slipped epiphysis of the head of the femur is strongly recommended in some cases by Schlesinger and Hansen (50). It

is in patients in whom appreciable slipping has occurred and the epiphyseal line is still not closed that most of the difference of opinion exists as to just what type of treatment, conservative or operative, should be performed. These patients are those in whom many bad late results have also occurred. Forceful manipulation and open reduction have given a high incidence of degenerative arthritis after several years whether or not aseptic necrosis had occurred. More recently a period of waiting has been advocated either with bed rest in traction or internal fixation, until the epiphyseal line is closed and then performing the corrective osteotomy. The results in these patients appear to have shown a distinct improvement. Another treatment which is recommended by the authors in this particular group of slipped capital epiphyses would seem to offer a method of reduction with less risk. They recommend skeletal traction by means of a beaded wire through the lower femur, allowing for a strong continuous pull in the long axis of the femur, with an additional pull in the direction of internal rotation. The beaded wire is applied with local anesthesia 3/4" above the medial condyle of the femur. The approach is from the medial side. A small skin incision is made and the wire inserted until the bead is felt to rest against the femur. The bow is then applied and the traction cord attached. A second cord is then attached to the lateral portion of the bow where it grips the wire, pull being made perpendicular to the femur in an upward direction. This supplies force in internal rotation and the bead prevents slipping of the wire. The authors present their experiences in four cases in which this technique was used. Excellent reduction and function was obtained in 3 cases. In the case where failure of this method occurred, open operation had to be resorted to.

For the tuberculous patient with advanced cavitation who has undergone posterior thoracoplasty and in turn later developed pain in the scapular area with a fixed scapula, Weisel and Cassel (51) describe a partial scapulectomy through an anterior approach. They have successfully employed a second-stage anterior thoracoplasty, together with partial scapulectomy and demonstrate that this is an excellent operation to further obtain collapse and to eliminate scapular complications, especially because the approach to, and the completion of the operation is simple and quick, which are factors of paramount importance in this type of patient.

A simple method of measuring and recording movements in joints is presented by Wright and Hilnes (52).

(Ed. note: No new methods but a combination of previous systems is used to make their system a very complete and thorough one. The equipment needed is readily available and for the details the reader is referred to their article.)

Joint measurement is described in detail by Occupational Therapist Hurt (53). The methods of measuring range of motion in various joints and precautions, with both 360 and 180° systems, are shown as to the expected normal range in degrees.

Dorinson and Wagner (54) present an exact technique for clinically measuring and recording joint motion. They have endeavored to present a standardized system of nomenclature after reviewing the literature. Measurements are made with the protractor goniometer, using skin-pencil marks

in the axis to be measured. The proposal is made that a joint measurement record should show full range; for example, in the normal knee "Extension - flexion 180° - 40°".

Hellebrandt and Skowlund and Kelso (55) present new devices for disability evaluation. The authors discuss the use of ergograms in evaluating disability of the upper extremity. The ergograms give visual evidence on a kymographic drum of range of motion and number of repetitions performed against test resistances of any motions being studied. It allows objective evaluation of initial incapacity, response to treatment and residual limitation. It may be of value ultimately in determining disability in cases in which compensation is a factor.

Better radiographs are discussed by Johnson (56), pointing out the basic factors involved in obtaining good diagnostic films. Four qualities essential to good films are: 1. Density. 2. Contrast. 3. Detail. 4. Minimal distortion.

Bone marrow biopsy is obtained by Loge (57) with the aid of a Klima-Schlicher sternal puncture needle. The marrow obtained is comparable in cellularity with that from the sternum. The method has the advantage of using a fixed bone and of being out of the range of vision of an apprehensive patient.

In an editorial, Dr. William Dameshek of Boston (58) in discussing bone marrow biopsy techniques feels that this diagnostic procedure is a necessary one, to be used frequently. In his clinic, preliminary observations of 30 comparative sternal, vertebral and iliac crest punctures indicate that the results are very similar and he feels that vertebral bone marrow puncture biopsy, as described by Loge, has a number of advantages.

Movable Horseshoe for Skeletal Traction

Dittrich (59) describes the use of the original Kirschner horseshoe to obtain tension on the wire, but traction is applied by means of separate hooks attached to the wire. This is designed to prevent rotation of the wire in the bone and safeguard against infection due to mechanical irritation.

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SECTION 20

RESEARCH

Prepared by Milton S. Thompson, Colonel, M. C., U. S. A.
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1. Metals and Plastics - Rubin, Robertson and Shapiro (1) note that pure polythene requires no plasticizers, is chemically inert, does not adversely affect body tissues, and is unaffected by temperature ranges of the human body. The material may be sawed, shaped and sanded, or melted and cast. It is sterilized by soaking in ethyl alcohol. The present report lists its use in nasal, chin, and forehead insertions (13 cases), and in one case of ear reconstruction. Illustrations show the excellent results obtained.

Bates and Reiners (2) plead for a trial of zirconium for use in surgery. They find it is extremely inert chemically and abundant in nature. Its electrolytic activity is about the same as tantalum and 18-8 SMO stainless steel. It can be drawn into rods and wire, rolled into plates, and machined into screws. Zirconium and tantalum have about the same physical properties. However, neither has the strength, ductility, nor elasticity of 18-8 SMO. Experimentally in dogs zirconium was tolerated well in bone and caused a minimal reaction. It is comparable to tantalum and stainless steel when used as a suture material.

Ingraham, Matson and Alexander (3) in an attempt to solve the problem of maintaining artificial sutures made in calvaria of sufferers from craniosynostosis, interposed five substances between artificial sutures in calvaria of monkeys and dogs to try to prevent reformation of synostosis. They used fibrin film, oxycel gauze, tantalum, lucite, and polythene. The latter three were all satisfactory from theoretical grounds but all offered practical difficulties except polythene. Reaction to it amounted to formation of a thin fibrous envelope and union of bone was prevented in all cases.

2. Bone Growth and Development - Anderson and Green (4) studied the normal growth of the femur and tibia in 255 children over a six year period. Several tables and curves are given showing normals and comparisons between boys and girls. Their roentgenologic technique is described.

Beal (5) studied the growth records of 201 diabetic children from 1920 to 1937 and compares them with normal growth records. Numerous growth charts and tables are presented. At 17 diabetic boys are 1.9 inches shorter than normal, girls 0.6 inches shorter.

Kaplan (6) measured the thickness of the laminae on 190 vertebral columns and found an average of 5.6 mm in the cervical spine and an average of 5.9 mm in the thoracic spine, the right being slightly thicker than the left in both regions. He found an average thickness of 6.5 mm in the lumbar spine, but here the left was slightly thicker than the right.

Washburn (7) measured the length of the pubis and ischium on 300 human skeletons of known race and sex. The pubis is shorter in negroes than in whites. The ischium-pubis index was calculated and averages 15% higher in females. He states that in over 90% of skeletons the identity can be determined by this index alone, provided major racial groups are treated separately.

Leggett (8) states that age determined by epiphyseal shadows is difficult and that few radiologists would care to be exact, even within a year.

Raven (9) in a discussion of the physiology of growth writes that intrinsic and extrinsic factors coordinate growth in vivo. The intrinsic factors determine the specific growth rate. This basic growth is modified by functional, mechanical, nutritive, nervous, and hormonal factors. A further factor exists in the difference in growth rates in an organ at different times. This has been termed "growth Gradient" which concept the author states is inaccurate, "as the growth of each point is characterized by at least three values indicating the growth in three perpendicular directions."

Chapchal and Zeldenrust (10) experimentally stimulated bone growth by introducing metal and ivory pins into the metaphyses of growing rabbits. The authors conclude that the method is not suitable for human practice because of its uncertainty, and its production of deformities.

Vastine, Vastine, and Arango (11) hypothesize that the size, shape, and contour of the skeletal system is predetermined by the genes since they find that in comparison of roentgenograms of respective bones of identical twins there is exact similarity in the detailed ossification of the costal cartilages, as well as in the fine bone details.

Sensenig (12) states that a study of human embryos from the Carnegie Collection shows the parts of the vertebrae are formed like cartilage elsewhere by a very dense aggregation of mesenchymal cells which have become enlarged and have indistinct boundaries. This is in sharp contrast to the development of the centrum of the vertebra which forms from a very loose aggregate of sclerotomic cells which form no compact precartilag mass.

Townsley (13) attempts to show that Wolff's law determines arrangements of bone substance at each stage in the evolving structure of the femur throughout the vertebrate kingdom and in the growing human femur.

Davis (14) presents a critique on methods of handling growth curves. He points out methods of selection of biological material and suggests means of portraying resultant data in a meaningful manner.

Dallenmagne (15) reviews the biochemistry of primary bone calcification and points out discrepancies in the original theory. He shows there are insufficient cations in the bone to combine with PO_4 and that the active cation is probably organic in nature. Ca/P ratio rises continually as microcrystals of tricalcium phosphate are progressively deposited in tissue rich in PO_4 ions. The Ca/P ratio of 1:29 cited by other authors is merely a stage along the time curve of ossification.

Paff (16) studied the femurs of 7 day chick embryos for two weeks at two different pH levels (i.e., pH 7.0-7.3 and pH 7.8-8.0) and found that more bone was formed at the lower pH. He claims his findings as strong evidence against the widespread belief that the local factor in bone growth is an alkaline pH.

3. Bone and Cartilage Grafts and Bone Healing - McKelvie and Mann (17) studied the tibias of rabbits microscopically, one to 120 days after transplantation of chipped cancellous bone from their own iliac crests. Alkaline phosphatase staining was employed and showed this enzyme absent for 10 days, then considerable activity ensued and abundant alkaline phosphatase was seen at the graft edges, with osteoblasts. This activity engulfs the dead chips and the osteoblasts effect their removal. It is pointed out that no alkaline phosphatase occurs in adult bone and that the osteoblasts become mainly the bone matrix, - "the fibrous-like non-calcifiable structure of adult bone". This enzyme is seen in relation to fibroblasts where no bone is being formed. They conclude that alkaline phosphatase aids in the formation of bone matrix, rather than in the deposition of calcified salts.

Steinman (18) studied embryonic bone transplants in rabbits attempting to eliminate external dynamic forces of Wolff's law by longitudinal drill holes. Drill hole defects were normally repaired without cartilage formation by intramembranous replacement. When the holes were grafted with living embryonic bone the defect was repaired in whole or in part by endochondral activity, frequently forming a large callus. Adult living and boiled bone show no cartilage formation. Whether the embryonic bone directly proliferates as chondrocytes or merely has a chemically osteogenic effect is not determined.

Bush and Garber (19) experimented with homogenous bone bank on chinchilla rabbits and learned that bone could be stored at 24°C for up to 84 days and still heal when grafted. They report a series of cases in which homogenous bone was used in 126 operations on 104 patients. Only 4 complications occurred; 2 infections, 1 fracture of an onlay graft, and 1 failure of soft tissue coverage. It appears that low temperature storage is a safe method of preserving bone for a long period.

Schram and Fosdick (20) report that they were able to stimulate healing in long bones by use of artificial material. Working with dogs, both ends of the radius were fused to the ulna; then 1 or 2 cm of the radius were removed and a tube composed of 95% tricalcium phosphate, 3% calcium carbonate and other mineral salts was used to fill the defect. This served to protect the initial blood clot, according to the authors, from invasion by surrounding differentiated tissue until calcification could take place. Bony union occurred in all cases. The experiment, they believe, demonstrates that the healing of bone originates in the primitive connective tissue of the initial clot.

Gordon and Warren (21) of Toronto carried out a study to ascertain the histologic reactions incurred when healthy young fetal actively growing cartilage is transplanted into adult long bone. The material consisted of cartilaginous epiphyseal ends of long bone of rabbit feti, diced in 0.5 mm cubes, and placed in defects of long bones of adult animals.

Results were studied by serial histologic sections taken at 4-day, 1-week, 2, 3, 6 and 12-week intervals. Examination of a 4-day posttransplant showed an absence of necrosis and actively growing cartilage cells. At one week the cartilage cells still filled the lacunae but the process of ossification continued. At 2 weeks cancellous bone surrounds the cartilage discs. At 3 weeks ossification continues. At 6 weeks continuity of bone and cartilage discs was seen. At 7 weeks the remains of the cartilage discs appear as islands of cartilage, walled off by cancellous bone with round cells in meshwork and walls of lacunae. At 10-12 weeks, islands of cartilage remain; cancellous bone was thickened and the mitosis of cartilage cells had disappeared. It is not the expected result of transplanted epiphyseal cartilage since bizarre exostosis did not result, but, even though these young cells of cartilage survive, propensity for growth is lost. Replacement of bone follows the already established scheme for autogenous cartilage grafts to bone. Erosion in areas between cartilage and bone, and round cell infiltration indicate some reaction to homogenous material. The reaction peak was 30-50 days after transplant. The authors reached the following conclusions: 1. Fetal rabbit cartilage when diced and grafted into long bones of adult animals will survive up to 3 months. 2. Slow replacement by cancellous bone occurs similar to autogenous grafts of cartilage. 3. No evidence, gross or microscopic, is found that fetal tissue after homografting retains any great propensity for growth or differentiation. 4. Mild local round cell reaction occurs, reaching its peak about 6 weeks after transplantation.

De Bruyn (22) made comparison between transplants of autoplasmic and homoplasmic bone in the thigh muscle of rabbits. No homoplasmic transplants formed bone. Of fresh auto-plasmic bone transplants, 11 of 23 formed bone; of bone marrow, 9 of 12 formed bone; of periosteum, 3 of 12 formed bone. Of the frozen autoplasmic bone transplants, 4 of 23 formed bone and none of 12 frozen periosteum transplants formed bone. This evidence is somewhat contrary to already existing evidence that transplant osteocytes do not participate in the bone formation but that osteogenic substances diffuse from the transplant.

Enneking (23) compared simple, complete fractures in rat tibias with partial "saw-cut" fractures in rabbit tibias. The complete fracture showed more hemorrhage and inflammation with the complete retardation of the endosteal response and partial suppression of the periosteal activity. No bone dissolution was noted. Repair was by a heavy external callus with chondrocytes arising from the periosteal fibroblasts. (Ed. note: An excellent description of bone reconstruction.)

Baker (24) presents a demonstration by photomicrographs of callus formation. In the healing of fractures the first sign of bone appeared within a week of injury. This bone is of a type called woven bone, which is laid down in an irregular interwoven pattern about the blood vessels of the granulation tissue instead of the lamellar arrangement of adult bone. The rapidly formed woven bone is replaced subsequently by adult bone. The formation of cartilage in the early stage depends largely on mobility of the fragments. Greater movement causes excessive cartilage formation with pseudoarthrosis. The trabeculae of "woven bone" in primary callus follows the haphazard plan of vascular distribution and the lamellar arrangement of adult bone is in accordance with the lines of stress.

Thompson, Ilfeld and others (25) report a clinical evaluation of the effect of ACS (antireticular cytotoxic serum) on the rate of healing of fractures in human subjects. Statistically significant x-ray improvement was observed but clinical observations were not sufficient to treat statistically.

Bacsich and Wyburn (26) found in the literature that muco-protein inhibits local leucocytic response of the host to bacterial invasion and conducted experiments to determine its role in survival of homografts of the cartilage and cornea implanted subcutaneously in guinea pigs. Muco-protein is present in large amounts in the interstitial substance of cartilage (chondroitin sulphuric acid). They assume that muco-protein plays an active role in maintaining homografts of cartilage intact in the host and suggest that homografts of other tissues would be more successful if it were possible to endow these tissues with some property of the muco-proteins.

Day (27) believes that alveolar bone is the most plastic of all bones, since the teeth are continually moving in the alveolar sockets, as a result of the various forces which act on them, and that it is constantly adapting itself to the changing requirements of the teeth.

4. Bone Formation and Destruction - Freedman and Forster (28) discuss bone formation and destruction in hyperostoses of bones of the skull with meningiomas. In general the literature reveals explanations based on trauma, vascular disturbances, or reactions of the bone to infiltrating tumor. Histologic studies are presented of seven cases which seem to indicate that bone growth and destruction is the function of the tumor cells which can produce fibroblasts, osteoblasts, and osteoclasts, or act as the latter two without apparent morphological alteration.

Amprino (29) describes the structural re-arrangement which takes place with age in ossified tendons of birds. From this he deduces that the structural re-arrangement of bone matrix depends largely on the continued deposition and resorption of mineral salts.

Evans, Lissner, and Pedersen (30) studied the patterns of stress when femora, coated with lacquer, were subjected to static or dynamically applied loads. The superior aspect of the neck and the anterolateral (convex) aspect of the shaft are under tension stress, while the opposite aspects are under compression stress. They suggest that this offers an explanation for fractures due to sudden violent muscle exertion.

Sherman (31) reports a case of a woman of 58 in whom many bones had almost disappeared as a result of Paget's disease and osteoporosis. Massive estrogen therapy was followed almost at once by a remission of clinical symptoms and by actual reconstitution of bone. Withdrawal of estrogen produced an exacerbation. Improvement again followed re-administration. A daily maintenance dose of from 2,000 to 10,000 rat units (0.33 to 1.66 mg) of estradiol benzoate was given with continued improvement and without untoward symptoms. Photomicrographs of sections taken from the bone before and after instituting estrogen therapy showed definite increase in the bone following treatment.

Colonna and Jones (32) produced caisson disease in rabbits and studied the bone to investigate pathogenesis of aseptic necrosis. The nitrogen bubbles in the marrow caused permanent cavities and are believed to be forerunners of aseptic necrosis of bone.

Rosin and Rachmilewitz (33) exposed bone marrow from rabbit tibias to mixtures of atmosphere containing from one to fifty percent oxygen. Microscopically, various degrees of degeneration and lessened mitotic activity were seen in concentrations of oxygen from one to twelve percent. Those in fifteen percent were similar to controls, whereas, those in fifty percent oxygen showed a marked increase in number of mature cells and degree of maturation.

Bywaters (34) describes a method of measuring bone opacity. It involves the simultaneous exposure of a graded series of radio-opaque cylinders. It is useful method of measuring bone rarefaction.

Campbell (35) studied electrolytic decalcification and observes that neither agitation nor placing the bone specimen at the positive electrode hastened decalcification. He feels that the electrolytic method is one of the best for preserving histologic detail.

5. Tissue Healing Studies - Lounsbury (36) conducted experiments to determine the tensile strength of tendon repair. The control dogs were placed in casts. One group broke out of their casts and showed 71 percent greater tensile strength at the end of six weeks than the controls. The groups in which muscle tonus was eliminated by denervation had thirty-seven percent less tensile strength than the controls.

Paul, Paul, et al (37) measured the water and protein content of the skin of rats during the repair of skin wounds. They found that the water content was higher during early stages of healing, approaching normal at about the 18th day, at which time wounds appeared healed. The protein content of scar was lower than normal in the early stages of healing and rose to normal at approximately the 18th day.

6. Vascular Studies - Kaplan (38) writes of the variations of the subclavian vessels. Normally the artery is behind and the vein in front of the scalenus anterior muscle. The muscle may be absent and the vessels in contact. Either the vein or the artery may be doubled or may form a ring with one branch or limb passing in front and the other behind the muscle. In rare instances there may be a reversal of the normal positions. (Ed. note: No percentages are given for the anomalies, but the author has found that the double artery or vein is the most frequent departure from the normal arrangement.)

Halperin and Co-workers (39) studied the effects of pneumatic cuff compression upon the blood flow in man. They used thermometric, blood gasometric, and plethysmographic methods for estimating blood flow in the extremities and found pressure as small as 10mm of mercury sufficient to reduce circulation in normal limbs. "Thus, pressure on the extremities, such as those ordinarily produced by snug clothing, gloves, shoes, bandages

or splints, or by the weight of the limbs themselves, or even the bed clothes upon the bony prominences, may be sufficient to cause significant reduction in the circulation of normal limbs."

Marple (40) summarizes the results of Barcroft and Edholm (Lancet, 2: 513, 1946) on their plethysmographic studies of vessels supplying forearm muscles. Their findings show that (a) relief of sympathetic vasoconstrictor tone in vessels and skeletal muscles doubles the blood flow; (b) heating the body relaxes the vasoconstrictor tone; (c) vasoconstrictor tone gradually returned to vessels in sympathectomized subjects; (d) vasodilation in the forearm muscles under such conditions as fainting and probably not exercise is a function of vasodilator nerves in sympathectomized subjects. Muscle contraction can bring about vasodilation.

Hollis, et al (41) made a comparison of three cases of peripheral vascular disease with respect to the blood flow in the lower extremities. They obtained greater increase of blood flow by sympathetic block of paravertebral ganglion than they did by intravenous injection of tetraethyl ammonium chloride in recommended dosages.

Harman (42) shows by means of experiments with rabbits that ischemic necrosis of skeletal muscle is not a major function of arterial spasm or venous obstruction, but of the persistence of initial ischemic damage to the capillary bed in the musculature involved. Angiographic and histological studies are presented.

Keplan and Joseph (43) determined the circulation rate in articular structures by increasing the temperature within the knee joints of dogs and observing the subsequent rate of cooling. They state that the normal circulation rate in articular structures is 0.75 cc per minute per cc of static fluid.

Wise (44) by plethysmograph readings shows that diathermy causes an increase in arterial blood flow to the segment of the body exposed to it.

Kemp, et al (45) found that diathermy applied to the hind limbs of dogs sufficient to elevate temperature, caused decrease of blood flow. When microwave energy was applied in the same way the blood flow was increased.

Kleinsasser (46) analyzes his observations of 502 cases of intravenous clotting seen in three large Army Vascular Centers. 12% of the cases presented no sequelae, 37.8% were partially disabled, and the greatest offender was persistent swelling. He is convinced that vasodilatation is necessary in treatment of thrombophlebitis; that propagation of thrombus and embolism must be prevented in phlebothrombosis. To avoid lymphedema as many collaterals as possible must be saved and early treatment is essential. Anti-coagulants should be started as soon as diagnosis of intravenous clotting is made, regardless of other modes of treatment chosen.

7. Muscle Histologic Studies - Hanisch (47) presents a general review of the anatomy, histology, and physiology of muscle in which a comprehensive, but rather elementary, compilation of the known facts about

normal muscle have been assembled in one article. Practically every aspect of the subject is covered except the gross anatomy of individual muscles and the sections on muscle action and muscle mechanics are especially valuable for the completeness and clarity.

Herman and Gwinn (48) studied histologically and chemically the necrosis of muscle in acute ischemia. It is noted that ischemia produces necrosis which reaches a maximum three hours after the tourniquet is removed and is proportional to the duration of the ischemia. Even when muscles are ischemic four hours, 80% regain ability to contract upon faradic stimulation after 24 hours. By chemical studies it was proven that glycogen, adenylypyrophosphate, and phosphocreatin, are completely hydrolyzed, and then are resynthesized in these muscles to some extent after 24 hours. They suggest that depletion of these compounds starts destruction of cells.

Johnson (49) studied the histogenesis of myositis ossificans in 70 cases. The early cases showed distinct layers, the center consisting of hemorrhage and debris, the first layer being the gelatinous myxomatous tissue, and the other layer being damaged muscle. The first layer rapidly forms two more layers, the outer one of which produces bone matrix and cellular activity resembling bone sarcoma until it ends as a shell of hard bone. The inner develops giant cells and resembles a giant cell tumor until it quiets down and ends as connective tissue. After the third month the histological appearance is definitely benign and many cases end with a hollow shell of bone.

8. Muscle Chemical Studies - Nicholas and Herrmann (50) in an article entitled "Chemical studies on developing muscle" studied the relative appearance of muscle protein in the rat from 12 days development to adulthood. Fractions were determined by extraction. Residue is 3.5% in the 12 day embryo, 5.5% at birth, 7% at 15 days, 6% at 27 days.

Steinbach (51) examined the role of the ions in muscles and their influence on muscle structure, fatigue, and the enzymatic systems. The author believes that intracellular cations are not evenly distributed within the cell's structure and that they show decided influence on the muscular enzymatic systems. Potassium and sodium were investigated carefully and very large changes in concentration will not impair the muscle's ability to perform work. He feels that these ions form a labile equilibrium with similar ions outside the cells. Structural adjustment of ions is made when this equilibrium is upset.

Acheson (52) in a discussion of the physiology of neuromuscular junctions from the chemical point of view, states that the most significant advances in neuromuscular studies has been in the electrical realm. A very detailed account of these developments is presented.

Acheson, et al (53) in an attempt to evaluate the sensitivity of myasthenia gravis patients to acetyl choline, administered it intra-arterially to five normal and five myasthenic subjects, and measured muscular contractions. It was concluded from the small series that there was no significant difference between the two groups. In fact, considerable variation occurred when the same dose was injected repeatedly in the same subjects.

Harvey (54) discusses the use of tetra-ethyl-pyrophosphate in the treatment of myasthenia gravis. It appeared to be just as effective as neostigmine. The effect of the potassium level as regards neuromuscular function is also discussed. He reports cases of both low and high serum potassium levels who developed an ascending type of muscular paralysis. This action, he feels, may be due to a primary defect in the muscles themselves.

9. Muscle Physical Studies - Sherman (55) reports his investigations with the development and treatment of contractures in the muscles of the cat's leg, following experimentally produced lesions of the sciatic nerve. The materials, methods, and types of treatment are given and the results are shown by several figures and tables. Immobilization of a normal extremity did not produce contractures. Following denervation, contractures began to develop in 30 to 45 days. Contractures occurred in 84.2% of the cases after primary suture and in 100% after delayed suture. Residual contractures were more frequent after delayed than after primary suture. Massage and passive motion decreased the frequency and severity of contractures. The addition of electrotherapy to massage and passive motion delays the appearance of contractures for a longer period of time after primary suture, and may have some benefit in the early post-operative period. Electrotherapy favors the development of contractures in the unparalyzed antagonists of paralyzed muscles, and retards the dissolution of contractures which occur after delayed suture. Contractures were more frequent following section of the sciatic nerve if the extremity was immobilized than if permitted to be free. Spontaneous movement after recovery of function serves to dissipate a contracture.

Kinard (56) found that in 33 subjects, who were trained, there was no significant degree of correlation between ischemic work ability and absolute muscle power. It is concluded that ischemic work ability and absolute muscle power are unrelated and probably depend upon different processes in muscle.

Alexander and Co-workers (57) report further experiments in bridging nerve gaps in monkeys. Thirty-two mm. gaps in tibial nerves were closed by nylon cables and embedded in tubulated blood bridges. Then re-innervated muscles regained an average of 85% of their normal weight. The distal re-generated nerve fibers were normal in number but subnormal in size. Functional recovery was grossly complete.

Schiller (58) studies bone changes produced by injury to peripheral nerves. In cats the sciatic nerve was sectioned below the sciatic notch. Bone changes were noted only when ulceration had occurred at heel or knee. These consisted of slight atrophy of the tarsal bones. Legs immobilized but without ulcers showed no demonstrable bone change. He concludes from the experiment that atrophy of bone does not result from denervation of an extremity nor from immobilization of a denervated extremity.

10. Phosphatase Studies - Kirk and Jackson (59) review calcium, phosphorus, and phosphatase metabolism, and the relationship of vitamin D, parathyroid extract and dihydrotachysterol. Phosphorus is decreased in hyperparathyroidism and rickets. It is increased in renal rickets and hypoparathyroidism.

The toxic symptoms recognized by Windaus, following the ingestion of large amounts of vitamin D are mentioned, and the two functions of vitamin D described as increasing calcium absorption and phosphorus excretion.

The same authors (60) review a series of hospital cases of hyperparathyroidism and Paget's disease and describe the symptomatology, physical and laboratory findings.

King and Delory (61) review the literature on phosphatases. Alkaline phosphatase in the absence of jaundice is associated with osteoblastic activity. Normal values vary with methods: Bodansky 1-4; Jenner and Kay, 3-8; King and Armstrong, 3-13. An increased level is typically present in Paget's disease, osteitis fibrosis cystica, rickets, and osteomalacia. The principal source of acid phosphatase is the action of the cells of the prostatic epithelium. Normal values are: Sullivan, 1-3; Watkinson, 1-5; Herbert, 1-5; Huggins and Hodges, 3.5 to 1.37. It is raised in cancer of the prostate while alkaline phosphatase level is normal.

Flink (62) discusses calcium, phosphorus, and phosphatase as diagnostic aids. Calcium varies in adults from 8.5 mg to 10.5 mg per 100 cc and in children from 11.5 mg to 13.5 mg. Serum phosphorus ranges from 2.5 to 4.0 mg per 100 cc in adults and from 0.5 to 5.5 mg in children. Osteoblastic activity accounts for the elevation of alkaline phosphatase in rickets, osteomalacia, Paget's disease, renal rickets, hyperparathyroidism, neurofibromatosis of bone, osteogenic sarcoma, carcinomatosis with bone metastases, Hodgkin's disease and Boeck's sarcoid. Jaundice, extensive fracture in the healing phase, and the last trimester of pregnancy can also cause increase in alkaline phosphatase. Low alkaline phosphatase is seen in cretinism and scurvy.

Hinchey (63) discusses the role of calcium in bone disorders. Theories of calcium metabolism are divided into four main categories as follows: (1) calcium absorption, (2) blood calcium, (3) calcium excretion, (4) calcium metabolism in bone. Various bone disorders are presented and discussed. Senile osteoporosis is thought to be due to a decreased osteogenic activity of the osteoblasts without a parallel retardation of decalcification. Osteomalacia is a failure of calcification of osseous matrix due to a lack of availability of calcium. Hyperparathyroidism may be an adenoma or hyperplasia of the gland. Hyperthyroidism involves the mechanism of lowering the renal threshold for calcium. Renal rickets causes acidosis and mobilization of calcium. Osteitis deformans is a local destructive process followed by compensatory new bone formation and exhaustive hyperparathyroidism. (Ed. note: This seems to be an excellent review of present thought on calcium metabolism).

Bourne, G. H. (64) shows that there is an accumulation of cells strong in phosphatase reaction in guinea pig bones within 24 hours after injury and that by three days these cells have nearly gone, but osteogenetic and endothelial cells are abundant. All cell types are reduced in number by four days in animals on a scorbutic diet.

Greep and co-workers (65) give a detailed description of the materials and procedures used in the decalcification of the hard tissues using the

heads and proximal portion of tibias of 28 day old rats. In evaluating the phosphatase activity, they determine that alkaline phosphatase could be demonstrated after decalcification in solutions of weak acid buffered to pH of 4.8 to 5 with the sodium salts of weak acids. Complete removal of mineral required 5 days and when the pH was lower than 4.78 the phosphatase was destroyed.

Fischer and Greep (66) present their work on the activity of purified alkaline phosphatase. They find that the activity lost by standing is restored temporarily by magnesium ions and more permanently by addition of amino acids or commercial trypsin, activation by the latter lasting the longest time. They state that their observation suggests that phosphatase is a metal protein.

11. Hormones and Enzymes - Vergara (67) studied five cases of osteoporosis with the following diagnoses: (1) slipped femoral epiphysis, (2) Legg-Perthes' disease, (3) developmental malformations, (4) congenital luxation of the hip and (5) juvenile rheumatoid arthropathy whose blood chemistry was normal. He treated them with anterior hypophysis growth extracts and later with extracts of the adrenal cortex and describes the satisfactory results achieved.

Collins and Becks (68) removed the hypophysis from one month old rats and studied them up to 639 days. Within 6 days chondrogenesis and osteogenesis ceased. Trabeculae are resorbed from the marrow of the diaphysis. The epiphyseal cartilage plate is separated by bone from the marrow cavities of the epiphysis and diaphysis and persists in this dormant state.

Becks, Asling, et al (69) report further studies of the third metacarpal in the hypophysectomized female rat. Pituitary growth hormone given to animals whose epiphyseal plates had been dormant for from 285 to 453 days was followed by replacement of the "sealing off bone" by capillary tufts. Thyroxin replacement caused closure of the epiphyses. The results were inconsistent and thyroxin was not essential.

The same authors (70) administered pituitary growth hormone to normal rats and found gains in body weight and length. The third metacarpal showed no increase in length. Epiphyseal closure was neither accelerated nor prevented. They conclude that the presence of an intact epiphyseal plate is thus not a criterion that growth potentiality exists.

Zarrow (71) studied the agents responsible for relaxation of the symphysis pubis and reviews the background regarding the role of relaxin and estradiol and progesterone. Using guinea pigs for the experiment he concluded that estradiol has a direct effect upon the symphysis and that treatment with relaxin injected into the estrogen primed guinea pig has a similar reaction.

Finkler and Cohn (72) report a case of multiple fibrous dysplasia of bone with hypogenitalism, treated with testosterone for one year. There were multiloculated cystic areas in all extremities, skull, ribs, and vertebrae. Treatment was continued for one year and a total of 2,200 mg of

testosterone given. There was improvement in general vitality of the patient and an increase in height and weight. There was also improvement in all bone lesions as shown by x-ray examinations and biopsy.

Kestler (73) reports the results of 314 orthopedic cases with muscular spasm treated by histamine. It was given chiefly by iontophoresis but supplemented in some instances by intravenous drip. They found that in functional disturbances the results are excellent and recurrences few. In specific entities such as arthritis, the results were temporarily good. He concludes that histamine iontophoresis is a harmless procedure and appears to eliminate painful muscle spasms.

12. Vitamin Studies - Mayer and Krehl (74) report that in their investigation of Vitamin A-1 deficiency syndrome in rats they observed symptoms of acute scurvy, i.e. bleeding of the lachrymal glands, red, swollen gums, and early paralysis of forelegs with swelling of joints. The symptoms subsided following massive doses of Vitamin C.

Silberberg, et al (75) found in growing Vitamin B deficient rats that there is retardation and finally cessation of growth of cartilage and bone and atrophy of the bone marrow. Skeletal growth is resumed after refeeding on stock diet.

Nelson, Sulon, et al (76) found in riboflavin deficient rats that the growth of the tibia was retarded and endochondral ossification impaired. Hematopoietic tissue was replaced by fat in all animals after 144 days.

Mulligan and Stricker (77) found that metastatic calcification was produced in various organs by feeding high doses of Vitamin D and alkaline salt. Without alkaline salt less calcification was found. Atrophy of testes, prostate, parathyroid, bone marrow, lymphoid, and adipose tissues were noted and relation to possible direct and indirect effects of Vitamin D was discussed.

Fourman and Spray (78) discuss a case of osteomalacia secondary to steatorrhea. A low fat diet (30 gr. daily) and supplemental calcium and Vitamin D gave no improvement. A diet with 70 gr. of fat, 4.6 gr. calcium, and 12,000 units Vitamin D by mouth caused retention of 1.9 gr. calcium in 16 days. When Vitamin D was given intramuscularly, 6 gr. of calcium was retained in the 16 day period. They therefore recommend parenteral Vitamin D and a diet as low in fat as is compatible with palatability.

13. Other Metabolic Studies - Johnston (79) reports two cases in which calcium was used as a therapeutic agent. The first was for tetany following thyroidectomy which was controlled with calcium lactate by mouth, calcium gluconate by intramuscular injections, and injections of parathormone. Calciferol was used later and is less expensive. The second case is one of lead poisoning with acute abdominal symptoms. 15 cc of a 20% solution of calcium gluconate was given intravenously which quickly controlled the abdominal pain. The lead was thereby stored in the bone and out of circulation for a few weeks and was again mobilized by giving a low calcium diet with potassium iodide or ammonium chloride.

Munro and Cummings (80) present an experimental study of nitrogen loss in traumatized femora in rats. Five or six days after injury the injured limbs were analyzed for nitrogen content. The total excess nitrogen output in the urine far exceeds that given up by the injured tissues.

Burnett, Burrows and Commons (81) studied kidney functions in osteomalacia resulting from renal acidosis - a syndrome called "tubular-insufficiency without glomerular insufficiency". The results suggest generalized renal impairment but greater relative tubular than glomerular dysfunction. The acidosis is partially explained by the inability of the kidneys to resorb all bicarbonate filtered at low plasma levels of this anion.

Hansen, et al (82) observed over a period of four years that young dogs maintained on a low fat diet show a lowered resistance to infection such as impetigo, pneumonia and purulent otitis.

14. Radiation Studies - Brues (83) gives a general discussion of the more common effects of the atomic explosion in Hiroshima. Sterility (usually temporary), acute radiation sickness, keloid formations, and aplastic anemia were cited. Treatment was discussed.

Rittenberg (84) summarizes the use of isotopes in biology and medicine and by specific example indicates the vast new fields of study made available through this technique. He clearly describes some of the newest detailed information on intercellular synthesis and degradation obtained by the use of labelled nitrogen.

McDonald (85) writes an introduction to the combined report of the Biochemical Research Foundation for 1947 and attempts to correlate what little is known concerning the mechanism of the action of radiation on living cells. He points out that the term radiation is applied to the widely varying action of visible light, ultra-violet light, x-rays, gamma-rays, neutrons, etc. Experimental work has shown that specific wave lengths of ultra-violet are far more lethal than an enormously greater amount of energy delivered by x-rays. He considers the cells as a series of colloid systems within colloid systems and states that we know little about what part of the vital system is affected by neutrons. The "quantum hit", or target theory, which has been advanced to explain variations in radiation effect, is that energy is absorbed in quanta and that lethal action depends on a sufficiently large number of quanta absorbed in a particularly sensitive spot of the cell. This he believes inadequate to explain variable cell effects. He concludes that when this mechanism of the action of radiation effects in stopping the growth and division of new cells is discovered, the problem of cancer will be well on its way to solution.

Doan, Wiseman, et al (86) make a six year clinical evaluation of internal radiation therapy with P32 on the first 100 cases. They state that the greatest value has been experienced in controlling the blood and clinical picture in polycythemia vera and in certain of the more chronic leukemic conditions, especially that group resistant to radiation therapy.

Silberstein (87) reviews the literature dealing with radium poisoning from 1908 to 1944. Seventeen deaths followed ingestion. Autopsy is described in nine. In all cases there was an advanced regeneration type of anemia, acute leucopenia, and degrees of bone destruction. Six deaths are ascribed to inhalation of radioactive dust 5 to 15 years after beginning of exposure. Dyspnea and pulmonary fibrosis were prominent signs with one having bronchial carcinoma. Distribution and deposition of radium is similar to that of calcium and lead.

15. Motion Studies - Levens, et al (88) report studies made on the transverse rotary motion of various segments of the lower extremities with synchronized photographic records made in three planes simultaneously with 35mm motion picture cameras of 26 normal subjects. Stainless steel pins were drilled into the iliac crest, the adductor tubercle of the femur and the tibial tubercle. They show that transverse rotation of the pelvis, femur and tibia occur in all normal individuals. Inward rotation takes place during the phase of minimal weight bearing to full weight bearing; and outward rotation during the phase from full weight bearing to minimal load. They believe that the discomfort and awkwardness of a leg brace with no rotation at the hip, knee and foot may be overcome by the incorporation of a simple mechanism to provide for this transverse rotation in amputees.

Pomeranz (89) studied the movement of the normal cervical spine in flexion and extension by x-ray. He shows that in hyperextension the spinous processes in the lower cervical area impinge upon each other while higher up they do not come in contact and that the apophyseal joints glide backwards as do the bodies. In hyperflexion, the spinous processes are widely separated, the facets move forward, and there is slight forward luxation of the third, fourth and fifth vertebrae in the normal spine.

16. Diseases and Malignancy - Messer (90) discusses chemotherapy of malignancies in a detailed manner. He describes the action of nitrogen mustard, urethane, radioactive isotopes, hormone therapy, toxin therapy, and other agents, and concludes that surgery remains the only permanent cure. Both radiation and chemical therapy are palliative measures at best and there is invariably a recurrence of the abnormal growth.

Faloon and Gorham (91) review the actions of mustard compounds biologically and chemically. In 15 patients with neoplastic disease who received 19 courses of treatment since November 1946, temporary remissions were obtained in treating cases of polycythemia vera, lymphosarcoma and Hodgkin's disease. Uniformly unsuccessful results in treating leukemias agree with the reports of other workers. The substance used was methyl-bis (beta-chloroethyl) amine.

Huss, Gilbert and Liebow (92) report a method of obtaining from the spinous processes, bone marrow for biopsy which they believe is more convenient and less dangerous than the method of sternal puncture. They state that it has additional value for the detection of metastatic tumor cells especially of prostatic carcinoma.

17. Chemotherapy - Altemeier, et al (93) studied chemotherapy in gas gangrene using artificially made wounds in guinea pigs and standardized

innoculations of Cl. Welchii. Streptomycin was found to have no significant value. Penicillin was shown to have a notable beneficial effect which was greatly modified by time of treatment and size of dose. Recommendations are that in suspected cases of gas gangrene, penicillin therapy should be instituted as soon as possible in conjunction with debridement at a recommended dosage of 1,000,000 units every three hours.

Klimek and co-workers (94) studied the resistance of staphylococcus aureus to various antibiotics. They were able to obtain a strain of staphylococcus aureus that grew in the presence of 4 mg of penicillin per ml, an increase of resistance of 80,000 times that of the parent organism. Resistance to streptomycin developed more rapidly. Various other substances were studied. Subculturing of a resistant strain in penicillin free broth reversed the process so that after 63 transfers the strain was again susceptible to 0.1 microgram per ml of penicillin.

Bellamy and Klimek (95) produced a resistant staphylococcus in which 54 transfers in the absence of penicillin did not decrease its resistance. An extra cellular penicillinase was produced when grown in the presence of penicillin. A reversion from gram-negative rods to the original gram-positive staphylococcus forms resulted after serial transfers through a medium containing glucose, salts, nicotinic acid, thiamine, and yeast extract. A minimum of resistance to penicillin was maintained.

Jones (96) reports his investigations of the use of local injections of penicillin into infected joints. He believes the intra-articular injection of 100,000 units effectively protects the joint for 48 hours, and is the only way of insuring proper concentration within the joint. Following intramuscular injection of penicillin the concentration in synovial fluid is less than in the blood. Parenteral penicillin injection should be used only as an aid to local use in joint infections.

18. Gas Gangrene - Caloow and Welch (97) subjected two series of dogs to devascularization of the hind quarters to study the prevention of gas gangrene. In comparison with a controlled group they reduced the incidence of secondary gas gangrene from 71% to 27% by (a) supportive therapy by intravenous fluid and transfusion during and after operation, (b) the preparation of the operative field as though the wounds were contaminated wounds, and (c) by improving the operative technique. Interpolated into terms of the devitalized limb in the war wounded, the findings seem to indicate that the adequacy of the preparation of the contaminated wound, the debridement and the operative technique were large factors in reducing gas gangrene infections without antibiotics.

19. Miscellaneous - Wilson (98) reports an experimental study of a technique of producing artificial bursae. Cellophane layers were used between the layers of a previously scarred subdeltoid bursa in 35 rabbits. The cellophane was left in the tissues 29 to 149 days. 23 of these rabbits developed a bursa composed of a normal appearing surface layer, supported by loose connective tissue. There was no sign of change in the cellophane and no foreign body reaction about it. The remaining 12 cases were unsuccessful because of complicating infection, extrusion or encapsulation of the cellophane.

Ingelmark and Blomgren (99) describe in detail a highly complicated electrical apparatus which can measure the pressure in different parts of a joint under conditions closely resembling the physiological state. A pressure sensitive element, consisting essentially of a rubber membrane, is placed between the cartilage surfaces. Measurement is by an electrical conductive method.

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SECTION 21

MISCELLANEOUS SUBJECTS

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Calcinosis, Vitamin D Toxicity, Heterotopic Bone Formation

The prescribing of massive doses of vitamin D is not without its dangers as shown in the case report cited by McLean and Lebo (1). The patient is a 56 year old white male whose chief complaints were tiredness, weight loss, lack of concentration, frequency of urination, insomnia, and pain in the neck, shoulders, knees, ankles, and feet. He had been studied two years previously at John Hopkins Hospital where the diagnoses were mild hypertension, osteoarthritis of the spine, and a chronic prostatitis. Upon his return home, his physician prescribed a streptococcus vaccine and 6 vitamin capsules a day. The total dose was 180,000 international units of vitamin A and 150,000 international units of vitamin D.

Examination showed his blood pressure to be 190/100. Positive findings were no limitation of motion of joints or deformity, but motion of the trunk caused pain in the thoracic and lumbar regions. There was a slight enlargement of the proximal interphalangeal joint of the right index finger and slight crepitation in both shoulder and knee joints. There was a moderate benign hypertrophy of the prostate. Blood and urine tests were essentially negative. X-rays of the cervical, dorsal and lumbar spines showed hypertrophic changes with extensive calcification of the spinal ligaments in the latter areas.

The patient returned home and continued treatment for osteoarthritis and hypothyroidism. Fifteen months later, 5 July 1946, he returned with an aggravation of his symptoms plus persistent nausea, weakness, swelling of eyelids and ankles, severe backaches and generalized itching. He stated that he had taken the above daily amount of vitamins A and D for two and a half years. For one month he noticed a lump in his right gluteal region and painful swellings of his left ring finger, thumb and wrist. He was admitted to the Union Memorial Hospital for study. He gave a history of twenty pounds weight loss and having difficulty in walking. Examination showed a pale skin and mucous membranes, a moderate hypertrophy of his heart with a grade I systolic apical murmur, peripheral blood vessels were sclerosed, the skin was dry and excoriated (from scratching). The left hand showed a cystic enlargement of the proximal interphalangeal joint and the tip of the ring finger. The wrist was painful to manipulation. There was a globular, cystic, protruding mass, orange sized, in right gluteal region which interfered with movements of the hip. Urinalysis showed a polyuria and a specific gravity which failed to go over 1.010. There was albumin and a few casts and white cells present. The Sulkowitch test showed 2 plus, and the phenolsulfonphthalein test showed a 6 percent excretion in one hour. Blood calcium was 9.01 mg; inorganic phosphorous

5.25 mg; alkaline phosphatase 6.85 Bodansky units; and acid phosphatase 28.08 and 27.01 Bodansky units. The Hb was 67 percent, and RBC 3,52.

The heart showed slight enlargement of the left ventricle; the aorta showed some calcification. There was a large area of increased density posterior to the upper portion of the shaft of the femur and intertrochanteric region on the right side. Streaks of calcification were noted in the soft tissue posterior to the ischia. The deep femoral and posterior tibial arteries were partly calcified. There were "areas of calcium density in the soft tissues of the left hand and wrist medial and posterior to the ulna and anterolateral to the proximal interphalangeal joint as well as the extreme tip of the fourth finger."

The gluteal mass increased in size and became more painful, so was excised. Multilocular cysts containing a chalky material was found. The cyst on the left ring finger was likewise treated, and the same type of material was found. The histological examination showed "calcium deposition, osteoid formation, and foreign body reaction". The calcium in the cysts and cyst walls was "surrounded by endothelial macrophages, foreign body giant cells and swollen fibroblasts". Throughout the sections there were large, polyhedral cells which were probably of osteoblastic nature. The diagnosis was multilocular cysts. The postoperative course was uneventful and following the withdrawal of vitamin D, his symptoms disappeared.

The symptoms of such a toxic manifestation are: "weakness, excessive fatigue, anorexia, weight loss, generalized pruritis, insomnia, and muscular pains; also clinical signs of renal failure, albuminuria, casts, failure of kidney to concentrate a urine with a specific gravity above 1.012, as well as reduced phenolsulfonphthalein tests. There was poor function of the excretion urogram, azotemia, metastatic calcification in the soft tissues and the blood vessels, anemia, and prostatitis."

The calcium and phosphorus blood levels were normal, but Freeman has stated that this may be preceded by an increased urinary calcium excretion. McLean and Lebo were unable to explain the high acid phosphatase. They recommend that in patients taking vitamin therapy an unexplainable renal insufficiency, anemia, or calcific deposits in the blood vessels or soft tissues should mean careful studies to rule out severe toxic manifestations of vitamin D poisoning.

The poisoning can produce symptoms and X-ray and laboratory findings of hyperparathyroidism, with or without bone changes, calcium deposition, and renal damage which may or may not be reversible. Slocumb (2) states that the earliest signs of vitamin D toxicity are "polyuria, polydipsia, nausea, vomiting, occipital headache, or pruritis", with laboratory findings of elevated serum calcium and blood urea and increased urinary excretions of calcium. Severe vitamin D poisoning produced deposits of calcium in nodules, tophi, and arteries, osteoporosis with destructive and cystic areas in bones, uremia, and anaemia. Dosages of vitamin D as low as 50,000 units daily may produce severe toxic reactions. Vitamin D is prescribed for a variety of arthritides such as osteoarthritis and gout as well as for rheumatoid arthritis, and toxic manifestations are becoming more common, with patients even going to surgery for parathyroidectomies.

Dr. Philip S. Hench of Rochester, Minn., states that "in a case of acute recurrent arthritis with nephritis or stones (radiographically non-opaque), think of gout, but in a case of chronic arthritis or even of vague "rheumatism" with nephritis or stones (radiographically visible) think of rheumatoid arthritis with pharmaceutic nephritis, chiefly vitamin D intoxication, and less commonly "gold nephritis". The poisoning does produce deposits of calcium in the media of the arteries.

The Pure Food Department cannot stop the sale of vitamin D preparations as long as these preparations are sold on prescription, so it is actually up to physicians to be aware of the dangers of vitamin D therapy and to prescribe it more wisely.

Edmonds, Coe and Tabrah (3) add a fourth case of mature, well-developed bone in skin, subcutaneous tissue, and muscle to three cases as occurring in children reported in the literature. Their case is a white female infant prematurely born 8 April 1944, weighing 3 pounds, 15 ounces. She was kept in an incubator for one month, and when removed had a small, hard, irregular area over the left breast. At the age of five months, a reddened, non-tender lump was noted at the tip of the left second finger. This was treated with hot packs. A month or so later, a small mass was noted in the left axilla. "At seven months raised areas suddenly appeared on the left forearm and on the dorsum of the left hand and continued to enlarge very slowly. At 18 months of age a particle of calcareous deposit was removed from the left second finger." This recurred. At 2 and 3/4 years, a particle was spontaneously extruded from the distal end of the left middle finger. "At three years, 5 months, a small lump was noted in the scalp at the crown of the head."

At age of 3-1/2, she was brought to the Children's Orthopedic Hospital, Seattle, Washington. X-rays showed calcification in the soft tissues of left axilla, arm, forearm, hand and fingers, and an "irregular destructive process at the distal end of the ulna with some periosteal reaction." "Masses were removed from the left hand, forearm, upper arm, axillary fold, and chest wall. Some of the masses were intracutaneous and others were in the subcutaneous tissue and were freely moveable. Some were firmly attached to bone, and some were within muscle or muscle sheaths. The masses were irregular, white, and varied in size and thickness. The distal joint of the middle finger was immobile with stony-hard, subcutaneous masses firmly attached to the skin and bone at the site of previous partial excision." Post-operative course was uneventful. Microscopic examination showed mature bone situated in the dermis, subcutaneous tissue, fascia and within muscle. "This bone possessed recognizable Haversian systems and centrally placed islands of well-formed red and fatty marrow. There were no inclusions of cartilage but small areas of osteoid at the periphery of the plaques where there were narrow mantles of fibrous tissue." The picture suggested congenital or developmental origin of aberrant bone.

Anesthesia in Orthopedics

Betcher (4) presents the use of Intravenous Procaine in a series of ninety-two patients. In this group he carried out 480 procaine infusions.

In a review of the history of usage of procaine it is interesting to note that Einhorn first synthesized Procaine in 1905, and since that time it has been used for: (1) Trigger areas; (2) Sprains; (3) In the treatment of fractures (local); (4) Neuralgia. Beer was the first to use Intravenous Procaine in 1908, however, World War II added impetus to its usage. Leriche in 1941, used Procaine for post traumatic pain, osteoporosis, traumatic arthritis and in painful amputations. Berthelomy, a French Medical Officer utilized it in frostbite and in fractures and dislocations.

Betcher employed the following technique: 0.1 to 0.2 gram of Procaine hydrochloride is dissolved in 500-1000 cubic centimeters of saline or glucose in distilled water. The procaine is administered in 10-50 drops per minute for the first ten minutes then 90-150 drops per minute until a relief of pain was obtained or toxic symptoms appeared. A usual dosage of four milligrams per kilogram of body weight was given. Initially sodium pentobarbital in .05-.1 gram was given prophylactically in order to reduce reactions but finally the authors abandoned this and merely kept it on hand. The typical reaction following intravenous administration of Procaine consisted of warmth, flush and a taste of a bitter metallic substance. Some patients experience nausea and dizziness and one patient presented swelling of the extremities and itching which responded well to Pyrabenzamine. There were no significant changes in pulse, blood pressure or respirations. The Intravenous technique was used in the following conditions with results as listed; each patient receiving at least two infusions and one patient sixteen infusions:

<u>Condition</u>	<u>Results</u>
1. Osteo-arthritis	Relief of pain and increase in range of motion
2. Rheumatoid Arthritis	No worthwhile effects
3. Traumatic Arthritis	Relief of pain with increased mobility
4. Bursitis	Some relief of pain with increased motion
5. Fractures	Relief of pain
6. Phantom Pain	Dulling of pain
7. Low Back Derangements	Variable. No effect in Disc Radiculitis
8. Muscular Spasm	Marked improvement
9. Congenital Spastics	Feeling of well being
10. Anterior Polio (old)	Feeling of relief
11. Intractable Pain (Bony Ca Metastatic)	Relief of pain, diminution of narcotics
12. Skeletal Pain of Questionable Etiology	Questionable
13. Pain, Postoperative, old	Temporary relief
14. Pain, Postoperative, acute	Relief of pain, decreased analgesic necessary
15. Causalgia	Questionable
16. Thrombophlebitis, chronic	Relief of pain and spasm
17. Indolent Ulcers	Increased blood supply with some evidence of healing
18. Reiter's Disease	No effect

Gordon (5) in addition to using Intravenous procaine for the relief of pain advocates its usage 200-500 milligrams toward the conclusion of surgery and he states that this frequently makes any further postoperative sedation unnecessary. He also advocates its usage in: (1) Postoperative traumatic dystrophy; (2) Urticaria; (3) Intractable hiccough; (4) Herpes zoster.

Brehm and Clay (6) discuss "Curare as an Adjunct to Anesthesia." Curare was popularized in 1942 by Griffith. Squibb manufactured Intra-costrin and Abbott d-Tubocurare. They bring out the fact that some of the confusion relating to dosage has resulted from units and milligrams being used interchangeably, when in reality they are not similar. They prefer the usage of curare, pentothal and nitrous oxide simultaneously. They list Myasthenia gravis as a contraindication for its usage and stress that facilities for respiration be convenient.

Sankey, Burdell and Campbell (7) in an article on "Various Anesthetics in Orthopedic Surgery" discuss the use of the various anesthetics commonly employed. Regarding Vinethene or Divinyl Ether they state that it has a limited use in Orthopedics and should be used only in those cases requiring a short acting anesthetic when profound relaxation is not required. It is not usually attended with nausea and vomiting upon recovery and it permits almost immediate ambulation. They do not administer Vinethene for procedures requiring more than ten minutes of anesthesia. A note of warning is brought out in that Goldsmith and his associates have demonstrated liver damage in dogs in procedures lasting more than one hour. They bring out the well known fact that Ethyl Ether in use now for 103 years is still one of the best anesthetics. They further discuss Nitrous oxide in combination with Pentothal and Curare; Cyclopropane, refrigeration in poor risk patients, and Regional anesthetics.

In their discussion of various anesthetics in Orthopedic Surgery they stress the utilization of combinations of anesthetic agents utilizing the beneficial qualities of several drugs. They conclude with the statement that, "Too much emphasis should not be placed on the anesthetic agent because the experience, skill and ability of the administrators is a factor of far greater importance than the particular agent employed."

Griggs (8) discusses the homeopathic therapeutics of curare and claims positive cures in the following types of cases: (a) post-diphtheritic palsy with inability to swallow; (b) respiratory failure of bulbo-spinal type of poliomyelitis, particularly intercostal type of paralysis; (c) respiratory failure in polioencephalitis.

Orton (9) gives a brief historical resume of controlled respiration and of curare together with a fairly complete description of the commonly accepted methods of controlled respiration and a discussion of the mode of action of curare and other anesthetic agents. The author believes that controlled respiration possesses advantages over voluntary respiration in thoracic surgery and also in abdominal surgery whenever the respiratory depression is apt to occur. The use of curare produces muscular relaxation and abolishes reflexes including the bronchial reflexes and allows the use of light anesthesia with its lessened incidence of shock.

Zimmerman (10) discusses the use of curare in anesthesia. Overdosage may cause progressive fall in blood pressure, respiratory failure, shock, and cerebral anemia. Antidote is prostigmine, 1-2cc of a 1-2,000 solution. Curare is so rapidly eliminated by kidneys that oral administration is ineffective. Curare may be used with any general anesthetic agent. Ether requires about 1/3 less. Adequate relaxation may be obtained with a lighter stage and plane of anesthesia. This improves the risk of certain poor risk cases.

Burke and Linegar (11) made a comparison of the pharmacological action of myanesin and curare in various animals. The effects are similar but curare seems to be less toxic than myanesin. The paralyzing action of myanesin is due to depression of the central nervous system, reaching above the spinal level, and to some slight peripheral or myoneural depression while that of curare is peripheral, being accomplished without significant vasomotor, cardiac, or central nervous system depression.

Griffith and Cullen (12) found myanesin to be as effective as curare in producing selective abdominal relaxation in the ratio of 10cc of myanesin being equal to 20 units of intocostin. No difference was noted in the selective action, duration of relaxation, respiratory depression, or toxic effects as compared with curare except that myanesin frequently produced local thrombophlebitis and a transient nystagmus. The authors conclude that myanesin is an effective and relatively nontoxic drug but that local irritation makes its continued use questionable since it possesses no advantages over curare.

Schlesinger, Drew and Wood (13) studied the clinical uses of myanesin exclusive of its use as an adjuvant to anesthesia. They found a 2% aqueous solution of the drug used intravenously obviated such toxic effects as phlebitis, abscess formation, and hemolysis. Side effects of nystagmus, blurring of vision, and circumoral numbness are uniformly present when the drug is administered in amounts of 50 to 100 cc of 2% solution at the rate of 30 to 40 drops per minute, but these are of interest only in determining clinically the therapeutic levels desired. Larger doses or more rapid administration may result in a state simulating decerebrate rigidity and may also cause cardiac arrest, but the margin of safety between therapeutic and toxic doses is much greater than with curare. The drug was tested in 123 patients exhibiting muscle spasm, rigidity, tremor, involuntary movements, acute poliomyelitis, herniated nucleus pulposus, acute vertebral dislocations, and Marie-Strumpell arthritis. In general the drug brought marked relief in all of these conditions with the chief site of action being in the spinal cord and brain stem. It has some hypnotic properties and local anesthetic action, but its effect on myoneural functions is minimal. Unfortunately, its effects are so evanescent and it is metabolized so rapidly that an effective concentration must be maintained by constant infusion. It is therefore impractical as a therapeutic agent in various spastic conditions, except to evaluate muscle spasm and deformities and as an aid in manipulating painful contractures and dislocations. Its usefulness in anesthesia was not explored in this study.

Bone Lengthening

Allan (14) presents an interesting, well-written article dealing with the ever present problem of leg length discrepancy. In a summary of the Historical Review he covers the work of Codivilla in 1905, who forced lengthening under narcotics by traction on the os calcis after an oblique osteotomy of the femur. Freiberg and Magnuson used modifications of similar methods. Putti in 1921 described a method of traction and countertraction and in 1927, Abbott described his method of tibial elongation. Some of the common complications encountered with these methods were: (1) Overstretching of nerves; (2) Interference with the blood supply to the fragments; (3) Insufficiency fixation of the fragments.

Allan states that his indications require that the shortening exceed one and one-half inches ($1\frac{1}{2}$ "). Any degree below this defect can be compensated by a pelvic tilt and shoe elevation. He lists the following contraindications to leg lengthening:

1. Cases in which there is poor control of the hip and knee joints.
2. Age, only carried out in adolescents and young adults.
3. Recent and chronic bone infection.
4. In very tall patients in whom shortening of the opposite extremity could be considered.
5. Faulty nutrition of the short limb.

His technique consists in utilizing a distracting apparatus modified after Haboush and Finkelstein. In forty-seven cases of tibial lengthening his average gain in the tibia was two and one-third inches ($2\frac{1}{3}$ ") and the greatest gain four inches. He produces an oblique osteotomy of the tibia leaving the periosteum as intact as possible and stressing minimal soft tissue damage. He avoids complete divisions of the soft tissue. The fibula is divided transversely at the same level.

He presents forty cases of femoral lengthening with an average of one and five-eighths inches ($1\frac{5}{8}$ ") and the greatest gain of three inches. The femur presented greater difficulty because of "troublesome knee stiffness." The reaction of bone to this procedure could be compared to that occurring in delayed fracture healing. Muscle responded poorly to lengthening with considerable wasting being present. The periosteum, membranes and fascia were most resistant to stretching. The blood vessels respond to slow stretching (the author stated that he attempted to gain one sixteenth inch ($1/16$ ") daily in distraction) but nerves did not respond as well. According to his experience the External Popliteal could be stretched two inches over a four to six weeks period without losing conductivity and a distance of three inches with only temporary impairment. Joint reactions were not noted about the hip in femoral shortenings but the knee joint tended to stiffen. In tibial lengthening the knee was usually unaffected. The author submits the following conclusions:

1. Two inches of lengthening may be gained in the femur and three inches of lengthening in the tibia without complications. More length can be obtained at the risk of temporary external popliteal paresis.

2. Lengthening of the tibia and fibula is easier to control than femoral lengthening.
3. Traction with countertraction through bone with complete lateral rigidity (casting) are essential to success.
4. Certain vascular complication experienced by other surgeons are attributable to subperiosteal bone exposure and to dividing the periosteum and fascial structures transversely.

Histopathology of Synovial Membrane

Paparella-Treccia and Monticelli (15) discuss the histopathology of the synovial membrane under three basic manifestations described by Lawen and Biebl:

1. Infiltrative form:
 - a. Localized (interstitial or perivascular)
 - b. Diffuse (predominantly lymphocytes-plasma cells-leucocytes)
2. Fibroblastic form:
 - a. Endothelial alterations (proliferative, cystic, degenerative)
 - b. Vascular proliferation
 - c. Fibroblastic
 - d. Fibrous regression, secondary or primary
3. The granular form

The authors state that Lawen's original work dealt with histological analysis of synovitis, meniscus lesions, degenerative arthritis and lues. He found fibroblastic degeneration in all conditions. The granular form was found only in synovitis and lues.

The authors describe their findings in biopsies taken from 12 knees and ankles in infantile paralysis. The cases are discussed briefly and are illustrated by excellent photomicrographs. The authors conclude that their most remarkable findings were prevalence of adipose tissue, abundance of blood vessels and scantiness of histiocytes.

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SUBJECT INDEX

- A -

- Acromioclavicular, dislocations, 328, 329
- Adamantinoma, 207
- Albright's Syndrome, 207, 208
- Amputations, 364-367
 - cineplastic, 365, 366, 367
 - forequarter, 367
 - sacroiliac, 367
 - spontaneous, 365
 - thigh, 367
 - tourniquet, 365
 - "turn-up-plasty", 367
- Anesthesia, curare, 414, 415
 - in orthopaedic surgery, 414
 - procaine, 412, 414
- Ankle, arthrodesis, 319
 - injuries, 316, 317
 - lateral ligaments, tear of, 315
 - recurrent dislocation of, 316
- Antitreticular cytotoxic serum, (exp.), 391
- Apparatus and new devices, 371-378, 380, 382
- Arch, anterior (metatarsalgia), 313, 314
 - longitudinal, 311, 312
- Arthritis, 56, 57, 66
 - allergic, 67
 - atrophic, treatment with diet, 74
 - brucellosis, 61
 - cervical, treatment of, 333
 - clinic, 59
 - deformans of hip, 72, 78
 - gold, distribution, exp., 71
 - in treatment of, 71, 74, 75
 - incidence, 59
 - infectious, 60, 153
 - neonatal, 61
 - rheumatoid, 64
 - after injury, 64
 - amyloidosis, 66
 - cardiac involvement in, 66
 - in children, 66
 - nodules, 65
 - peripheral circulation in, 72
 - prothrombin time in, 66
 - pulmonary osteoarthropathy, 65
 - psychosomatic, 65
 - streptococci agglutination in, 71
 - treatment, with transfusions, 72
 - by desensitization, 74
 - comprehensive, 73
 - with periostitis of os calcis, 65

Arthritis, Marie-Strumpell, 231, 232
Arthropathy, diabetic, 70
 neuropathic, 70
 psoriatic, 70
Aseptic necrosis and Caisson Disease, (exp.) 392

- B -

Back ache, 229, 235, 237
 sciatic syndrome in, 223
 thoracolumbar syndrome in, 275
 treatment of, 276
Back pain, in lower portion, 219, 220, 221, 228, 233
 due to herniation of fascial fat, 265
 due to narrow intervertebral foramina, 240
 gynecologic, 221, 222
 traumatic radiculitis, 230, 231
 treatment, novocaine in, 243
 operative aspects of, 259
 operative results in, 245
Biceps brachii, insertion of, 359
 long head of, rupture of, 332
Bone and cartilage grafts, (exp.), 389, 390
Bone calcification, 396
Bone cyst, 208
Bone defects, bridging of, 379
Bone formation and destruction, (exp.), 391
Bone formation and hormones, 72
Bone growth, ossification centers in, 20
 retardation of, 20, 21
Bone growth and development, (exp.), 387, 388
Bone healing, (exp.), 390
Bone lengthening, 416
Bone marrow, puncture for obtaining, 382, 400
Bone metastasis, 206, 207
Bone opacity, 392
Bone tumors, diagnosis, 205
 incidence, 205
 pathology in, 205
 sacrum, 212
 surgery in, 205
 vertebral column, 205
Brachial plexus injury, 331
Brodie's Abscess, 48
Bursae, artificial, (exp.), 401
Bursitis, Boxers, 69

- C -

Caisson disease, (exp.), 392
Calcium metabolism, 396
Calvé's disease, 242

- Carpus, cyst-like lesions, 356
 - dislocation, 347, 348
 - excision, 353
- Cartilage, 22, 380
- Causalgia, 137, 138, 139, 140, 141, 142, 143
- Cerebral palsy, 131, 132, 133
- Cervical, brachial pain, 335, 336, 338
 - discs, 332, 333, 334
 - ribs, 338, 339
 - root, 335, 336
 - spinal cord injuries, 335
 - spine motion, 400
- Chemotherapy, 400
- Chest, closure after surgery, 272
 - funnel, 271
 - sternochondral joints, 272
 - wall tumors, 271
- Chondrodystrophy fetalis, 212
- Chondroma, hand, 211
 - lumbar spine, 212
- Chondromyxoid fibroma, 211
- Circulation in joints, (exp.), 393
- Clavicle, pseudarthrosis of, 332
- Coccyx, painful, 238
- Congenital, absence of bones, 5, 7, 11, 14
 - anomalies and malformations, 5, 9, 14, 16
 - arthrogryposis, 12
 - causes of, 8
 - club foot and metatarsus varus, 6, 16
 - defects, in lower extremity, 9
 - deformity, spine, 11, 14
 - dislocation, hip, 1, 2, 3, 4, 7
 - osteodystrophy, condensing, 13
 - peripheral nerve paralysis, Erbs palsy, 5
 - pseudarthrosis, clavicle, 332
 - tibia, 15
 - shoulder, 6, 12
 - synostosis, 11
 - torticollis, 9
 - costoclavicular compression, 339
- Coxa plana (Calvé-Perthes-Legg's Disease), 279, 280, 281
- Curare, in paralysis agitans, 126
 - in spasticity, 126
- Curare and myanesin in anesthesia, 414, 415

- D -

- Decalcification, electrolytic, 392
- Deformities, after trauma, 196
- Devices, new and apparatus, 371-378, 380, 382
- Disability evaluation, 382
- Dysostosis, metaphyseal, 23
- Dystrophy and pain in extremities, 144

- E -

Elbow, arthroplasty, 355
 contractures, 355
 denervation, 357
 dislocation, 159
 injuries of, 348
 tennis, 356
Electric interaction, between nerve fibers, 144
Engelmann's Disease, 13
Epiphysis, upper femoral slipping, 281-287
 beaded wire in treatment of, 380

- F -

Fibrositis, 68, 226
Fibrous dysplasia, 207, 208
Finger, mallet, 348, 349
 reconstruction, 351
Forearm, rotation, 354
Foot, accessory bones, 317
 dislocation of, 314, 315, 320
 flat, 311, 313
 spastic, 312
 injuries of, 316, 317
 postural defects of, 313
 stabilization, 320
Fractures and/or dislocations, 157-195
 acetabulum, 165
 ankle, 176, 177
 calcaneus, 177, 178
 callus pattern in long bones, 187-189
 carpus, 161, 162, 163, 353
 clavicle, 157
 with arm pain, 339
 elbow dislocation, 159
 experimental study of sites of, 187
 external skeletal fixation in, 181, 182
 femur, neck of (hip), 164, 169, 170, 171, 172, 182
 shaft, 173, 178, 179, 180, 184
 fibula, dislocation of head, 175
 shaft, 176
 hand, 162, 163
 humerus, 157, 158
 supracondylar, 158
 metatarsal, 177
 parachute jumping, 187
 patella, 174, 175
 pelvis, 185
 radius, Colles, 160
 head, 159
 lower epiphysis separation, 161
 radius and ulna, 160, 161
 rib, 185

- scapula, 157
- spine, 184
- tibia, 175
- treatment of, 186, 187
 - compound wounds, 185
 - emergency, 186
 - minor fractures, 186
 - plates in, 183
 - screw fixation in, 182
 - types of fixation in, 183
- trochanteric, 166, 167, 168, 172
- ulna, 160
 - olecranon, 159
- unrecognized, 187
- xiphoid, 185
- Fracture deformities, 196-204
 - treatment of, bone grafts, 198, 199, 200
 - malunion, metacarpal, 198
 - united, clavicle, 197, 199
 - neck of femur, 201, 202,

- G -

- Gas gangrene, (exp.), 400, 401
- Gaucher's disease, 25
- Genu valgum, 303
- Giant cell tumor, 205, 207
- Gout, 69, 70
- Graft, double notch for spine, 379

- H -

- Hand, Dupuytren's contracture, 354, 357, 358
 - fibrosis, 349
 - gangrene, 350
 - infection of, 349
 - injuries of, 346, 347
 - muscles, innervation of, 357
 - posttraumatic edema in, 350
 - reconstruction of, 348, 350, 351, 352, 354
 - surgery of, 350
- Heberden's nodes, 69, 358
- Heels, curator, 314
 - painful, 314, 317, 319
- Hemangioendothelioma, 211
- Heterotopic bone formation, 412
- Hip, arthrodesis of, 295-298
 - arthroplasty, mold, 292
 - evolution of, 291
 - study of, 291, 292
 - aseptic necrosis in, 293, 294
 - bony ankylosis in, 295

- dislocation, pathologic, 288
 - traumatic, 289, 290, 291
- lesions of infants and children, 286
- obturator nerve avulsion for pain, 287
- osseous changes in paraplegia, 288
- osteotomy, Leadbetter, 293
 - spike, 293
- vacuum phenomenon, 287
- Histamine and muscular spasm, 398
- Homografts, 379
- Hormones and enzymes, 397, 398
- Hyperostosis, infantile cortical, 21, 22

- I -

- Infections, extremities, 52
- Intervertebral disc, complications of surgery in, 257
 - rupture in cervical region, 264
 - rupture in lumbar region, 245-266
- Intervertebral ligaments, 275

- J -

- Joint, disease, degenerative, 68
 - measurement, 381
 - pressure, 402

- K -

- Knee, anatomy, 302
 - arthrodesis, positive pressure, 306
 - arthroplasty, 306, 307
 - cartilage response to trauma, 306
 - cruciate ligaments, 303, 304
 - diagnosis, 302
 - fixed extension, 303
 - innervation of, 302
 - internal derangements of, 304, 305
 - meniscectomy, 306
 - changes after, 305
 - meniscus, anatomy, 307
 - calcification, 305
 - discoid, 303
 - pneumoarthrography of, 302
 - popliteal varices, 304
 - pyarthrosis, 304
 - synovectomy, 307
 - tibial condyle fracture, 304
 - treatment of, injuries of, 304
 - surgery in, 305

- L -

Leontiasis ossium, 26
Leprosy, bone and joint lesions in, 51
Leukemia, skeletal lesions in, 207
Lipoid granulomatosis, 212
Lumbar, disc, 244
 facetectomies, 244
Lumbosacral spine, pseudoarthrosis after fusion of, 240, 241
 X-ray study of, 241, 242
Lumbosacroiliac arthrodesis, 243

- M -

Malignancy and chemotherapy, 400
Melorheostosis, 23
Metabolic studies, 398, 399
Metals and plastics, 387
Motion studies, 400
Multiple sclerosis, 149
Muscle, atrophy, 146, 147
 chest, pain syndrome, 148
 disease, 145
 dystrophy, 146, 151
 palmaris longus, 356
 pretibial necrosis, 316
 relaxants, 125
Muscle, chemical studies, (exp.), 394
 histologic studies, (exp.), 393, 394
 physical studies, (exp.), 395
Myalgia, epidemic, 148
Myanesin, 127, 415
 in treatment of neuromuscular disorders, 125, 126
Myasthenia gravis, 134, 135, 136, 394
Myeloma, multiple, 209
 mandible, 209
Myositis ossificans, 394
 progressiva, 14

- N -

Nails, 354
Neoplasm simulated by chronic bone lesions, 51
Nerve, to extensor hallucis longus, 311
Nerve, median, compression of, 358
Neuritides, 130, 131
Neurofibromatosis, 25
Neuromuscular disorders, physiology of, 124
 treatment of, pharmacological agents in, 127
 physical medicine in, 145
 reeducation in, 150
Neuropathic joints, 338
Neuropathy, primary sensory, 149

Ollier's disease, 207
Osgood-Schlatter's disease, 26, 27
Osteitis, acute, 43
 ~~hematogenous,~~
 pubis, 48, 50
Osteitis deformans (Paget's Disease), 29
Osteitis fibrosa, 208
Osteoarthritis, 68, 69, 77, 78
 cervical spine, 69
 fingers, 69
 metacarpo-trapezium joints, 355
Osteoarthropathy, 69
Osteochondroma, 206, 271
Osteogenesis imperfecta, 10, 15, 27, 28
Osteoid osteoma, 207
Osteoma, 207
Osteomyelitis, acute, 44, 45, 46, 47
 brucellosis, 50
 chronic, 50
 antibiotics in, 43, 44, 45, 46
 treatment of, 46, 47,
 coccidioidal, 50
 face and skull, 48, 50
 hematogenous, acute, treatment in, 45, 46
 hypertrophy of bone in, 47
 newborn infant, 47
 paratyphoid and typhoid, 49
 salmonella, 49
 sclerosing, non-suppurative, 47
 spine, 48, 50, 274
 statistics, 46
 treatment of, 44
Osteopetrosis, 22
Osteopoikilosis, 23
Osteoporosis, 23, 24, 25
Osteotomies, corrective, 378, 379

Paget's disease (osteitis deformans), 29
Pain and dystrophy in extremities, 144
Paralysis, acute ascending, 147
 serratus anterior, 131
 serratus magnus, 146
Paraplegias, treatment of, 147, 274
Pararheumatic diseases, 63
Patella, chondromalacia of, 305, 307
 excision of, 307, 380
Peripheral nerve injuries, 127, 128, 129, 130, 137
Phantom limb, 367

Phosphatase, 395, 396, 397
 Physical therapy in arthritis, 80
 Plastic surgery, 380
 Plastics and metals, 387
 Plastocytoma, 209
 Poliomyelitis, 95, 96, 97, 99, 101
 acute phase of, 97, 101
 case analysis in, 97
 clinical manifestations of, 96, 106, 109
 complement-fixation in, 103
 diagnosis of, 107, 108
 electromyographic studies in, 116, 117
 epidemic, 98, 99, 100
 epidemiology in, 99, 100, 101, 102
 experimental, 102, 105
 fatal cases in, 98
 follow-up examinations in, 97
 growth failure in, 113, 114
 incidence of, 101
 in infant, 109
 medical considerations in, 96
 nerve fiber studies in, 117
 neutralizing antibodies in, 103
 pathogenesis of, 101, 102, 103, 105
 pregnancy in, 109
 preparalytic stage of, 97
 recurrent, 108
 sedimentation rate in, 105, 106
 terminology of, 109
 test for virus in, 102
 treatment of, 109, 110, 111, 112, 113, 114, 115
 bulbar, 111
 curare, 111, 112
 muscle, reeducation in, 116
 muscle, transplants in, 115
 neurotripsey in, 117
 physiotherapy in, 115, 116
 reconstruction, 115
 thermal antibody, 112
 Polyarthrititis, 61
 Posture, 271
 Prostheses, 368

- R -

Radiation studies, 399
 Radicular pain in upper extremity, 357
 Radiographs, 382
 Rehabilitation in arthritis, 80, 81
 Reiter's syndrome, 61, 62
 Rheumatic fever, 63
 Rheumatic lesions, 65

Rheumatoid disease, 65
Rheumatism, 57, 59
 aged, 59
 diagnosis, 66
 in pregnancy, 64
 industrial aspects, 59
 palindromic, 68
 procaine in treatment of, 74, 79
 psychogenic, 70, 71
Rickets, 21

- S -

Sarcoidosis, 210
Sarcoma, bone, 206
 diagnosis of, 205
 Ewing's, 206
 Paget's disease and, 206
 simulation of, 211
 treatment of, 205, 206
Sarcoma, synovia, 208
Scalenus anticus syndrome, 336, 337, 338
Scalenus medius pain, 338
Scaphoid fractures, 356
 treatment of, 353, 354
Scapula, removal of, 381
Scheuermann's disease, 272
Sciatica and sciatic pain, 223, 224, 225, 235, 238, 260, 264
 diagnosis of, 229
 neurofibroma of cauda equina in, 237
 spinal fusion in, 235, 236
Shoulder, anatomy, 324, 325
 axial projection in, 327
 degenerative lesions of 329, 330
 dropped, 331
 frozen, 330, 331
 painful, 330, 331
 transplants, 332
 dislocation, 328
 fracture, 331
 old, 328
 posterior, 327, 328
 recurrent, 325, 326, 327
 epiphyseal slipping, 332
 girdle syndrome, 147
 hand syndrome, 144, 340
Sickle cell anemia, bone changes in, 29
Spinal cord injuries, bone disturbances in, 274
Spine, anomalies, 271
 fusion of, with screws, 379
 lateral curvature of, (scoliosis), 272, 273
 osteomyelitis of, 274

Spondylitis, ankylosing, 67, 77
Stellate ganglion block, 378
Subclavius muscle and neurovascular syndrome, 339
Supraspinatus tendon, 330
Suture, delayed for wounds, 378
Syndactyly, 354
Synovioma, 208
Synovial membrane histopathology, 417
Syphilis, bone, 51

- T -

Tendon, injuries, hand, 353, 356
 repair, 380, 392
 stenosing tendovaginitis, 357
 tenosynovitis of, 350
 transfer, in hand, 352, 353, 354
Thumb, movements, 356
 reconstruction, 351, 352, 353
Tissue healing, tendons, 392
Toe, hallux valgus, 314
 hammer, 319
Tuberculosis, 33
 antibiotics, 34
 streptomycin, 34, 35, 36
 BCG vaccine, 33
 greater trochanter, 38
 hip, 38, 39
 multiple cystic, 39
 nursing in, 33
 rheumatism, 39
 sinuses and abscesses, 35, 39
 spine, 36, 37, 38
Tumors, malignant, of soft tissues, 212

- V -

Vascular studies, 392, 393
 subclavian vessels, 392
Vitamin D administration, 410, 411
Vitamin studies, 398

- W -

Warts, plantar, 317, 318
Wrist, disorganization, 349
 fusion, 354

- X -

X-ray therapy in arthritis, 76, 79
Xanthomatosis (Hand-Schüller-Christian disease), 25, 212

AUTHOR INDEX

- Abercrombie, R. G., 261
 Abramson, A. S., 274
 Abt, A. F., 107
 Ackerman, A. J., 206, 210
 Acheson, G. H., 394
 Acosta, E., 51
 Adams, J. C., 318, 325
 Adams, J. D., 183
 Adams, R. D., 316
 Aegerter, E., 25
 Agerholm, M., 45
 Ainsworth, W. H., 187
 Albers, E. A., 67
 Albright, F., 23, 72
 Alexander, E. Jr., 387, 395
 Alexander, F., 65
 Allan, F. G., 416
 Alldredge, R. H., 365
 Allen, A. L., 43
 Allen, L., 377
 Alston, J. M., 35
 Alpern, E. B., 208
 Altavas, R., 365
 Altemeier, W. A., 400
 Altenberg, A. R., 379
 Alter, M. S., 68, 378
 Amberson, J. B., 34
 Ames, S. R., 151
 Amprino, R., 391
 Anderson, H. C., 33
 Anderson, H. H., 34
 Anderson, J. C., 163
 Anderson, M., 387
 Anderson, R. L., 163
 Ahdreasen, A. T., 14, 158
 Andren, H. E., 149
 Angerholm, M., 45
 Annersten, S., 197
 Applegren, A., 67
 Applequist, A., 67
 Applequist, O., 72
 Appley, A. G., 312
 Arango, O., 14, 388
 Armer, A. I., 48, 50
 Armstrong, A. C., 355
 Armstrong, J. R., 289
 Arvola, A., 97
 Asling, C. W., 397
 Asling, R., 185
 Austin, G., 260
 Aven, C. C., 35
 Aycock, W. L., 100
 Ayers, W. W., 208
 Ayyar, N. S. W., 196
 Bach, T. F., 57, 59, 60, 64,
 66, 68, 69, 73, 75, 76,
 91, 233
 Bacsich, P., 391
 Badgley, C. E., 281, 294
 Bailey, A. A., 131
 Bailey, E. T., 377
 Bailey, J. H., 401
 Baird, C. L., 208
 Baker, D. M., 78, 313
 Baker, D. R., 182
 Baker, F., 6
 Baker, D. M., 313
 Baker, G. S., 209
 Baker, L. D., 231, 297
 Baker, S. L., 390, 27
 Baker, R. T., 209
 Baker, S. L., 27
 Baker, W. J., 209
 Bakhsh, A., 256
 Balensweig, I., 60
 Ball, L. H., 314
 Ball, R. E., 56
 Bang, F. B., 148
 Barnard, L., 354
 Barnes, R., 114, 335
 Barns, H. H. F., 237
 Barnwell, J. B., 35
 Barr, J. S., 114
 Barsky, A. J., 351
 Barta, C. K., 283
 Bartter, F. C., 72
 Basom, W. C., 51, 372, 378
 Batchelor, J. S., 81, 339

Bateman, J. E., 332, 357
 Bates, J. I., 387
 Bateson, S., 375
 Bauer, W., 58, 73
 Bauman, E., 76
 Bayles, T. B., 73, 75
 Baylin G. J., 210
 Bazliel, I. R., 354
 Beal, C. K., 387
 Beard, E. E., 69
 Beath, T., 311
 Beck, G. S., 66
 Beck, O., 399
 Becks, H., 37, 47, 397, 398
 Begg, A. C., 253
 Beerman, C. A., 45
 Behrend, H. J., 330
 Bell, L. G., 135
 Bell, L. H., 314
 Bellamy, W. D., 401
 Beller, A., 212
 Bellis, C. J., 52
 Benians, R. G., 68
 Bennett, A. E., 136
 Bennett, R. L., 111
 Berg, R., 271
 Berger, F. M., 125
 Berkett, G. D. B., 280
 Berman, L. S., 50
 Bernard, Z. A., 353
 Bernstein, L., 286
 Bernstein, S., 35
 Bertrand, J. J., 71
 Betcher, A. M., 412
 Betts, R. H., 209
 Bick, E. M., 187
 Bickel, W. H., 36, 38, 293
 Bickers, D. S., 126, 376
 Bikoff, A., 112
 Bingham, J. A. W., 367
 Birch, C. A., 49
 Birdsong, M., 39
 Bisgard, J. W., 365
 Black, H. A., 259
 Blackwood, W., 335
 Blair, H. C., 365
 Blake, H. E., 352
 Bland, E. F., 273
 Blattner, R. J., 111
 Blazer, A., 76
 Bledin, B., 339
 Block, W. D., 71
 Blomgren, E., 402
 Blosser, J. A., 400
 Blum, L., 319
 Bock, A. V., 64
 Bodian, D., 105
 Bogdanovitch, A., 61
 Bograd, N., 338
 Bohlman, H. R., 377
 Boland, E. W., 64, 70
 Bonnin, J. G., 162, 316, 350
 Boone, R. R. Jr., 376
 Boots, H. R., 76
 Borak, J., 76, 79
 Borreelli, F. J., 11
 Bosma, J. F., 113
 Bost, F. C., 1
 Bosworth, B. M., 329
 Bosworth, D. M., 167, 240
 Bouman, H. D., 116
 Bourne, G. H., 396
 Bowden, L., 205, 206
 Bower, A. G., 74
 Bowman, J. R., 135
 Boyd, H. B., 15, 165, 380
 Boysen, G., 224
 Bradford, F. K., 245
 Bradley, W. H., 97
 Brailsford, J. F., 205
 Brain, W. R., 269
 Brandt, S., 12
 Brashear, C. E., 368
 Brav, E. A., 241, 315
 Breck, L. W., 51, 372, 378
 Brehm, W. F., 414
 Briggs, H., 259
 Bringold, A. C., 208
 Brittain, H. A., 296
 Broadbent, B., 100
 Brock, B. L., 35
 Brockbank, W., 328
 Brookin, H. A., 271
 Brokaw, 81

Brooks, H., 208
 Brooks, D. H., 72
 Browder, J., 367
 Brown, G. C., 101
 Brown, H. J., 161
 Brown, J. B., 380
 Brown, R., 274
 Brown, S. W., 205
 Browne, D., 4
 Browne, W. E., 346
 Brownlee, G., 34
 Brues, A. M., 399
 Burgsch, H. G., 74
 Bruner, J. M., 352
 Brunner, H., 48, 207
 Bryson, A. F., 288
 Buckman, J., 45
 Buckley, C. W., 59, 67
 Bucy, P. C., 333
 Bull, J. W. D., 269
 Bunin, J. J., 60
 Bunnell, S., 354
 Bunts, A. T., 150
 Burke, J. C., 415
 Burman, M., 353
 Burnett, C. H., 399
 Burrows, B. A., 399
 Burrows, H. J., 176
 Burrus, S. Jr., 146
 Bush, L. F., 389
 Butler, A. A., 354
 Butler, E. D., 221
 Butterworth, R. D., 332
 Buxton, R., 70
 Bywaters, E. G. L., 67, 392

Cady, J. B., 166
 Caffey, J., 9
 Caldwell, G. A., 255, 378
 Callaghan, J. J., 177
 Caloow, A. D., 401
 Cameron, C., 210
 Camp, J. D., 69
 Campbell, M. K., 392
 Caniza, A. P., 170
 Capener, M., 67
 Carlton, C. H., 163
 Carlton, H. H., 367
 Carpenter, E. B., 332
 Carroll, G. V., 371
 Casey, A. E., 96
 Cash, P. T., 136
 Cassell, M. A., 381

Casterline, R. F., 209
 Caughey, J. E., 96
 Cavallito, C. J., 401
 Cave, E. F., 37, 304
 Chance, G. Q., 140, 144
 Chandler, F. A., 294
 Chang, P., 207
 Chanton, E. F., 393
 Chapchal, G., 388
 Charnley, C. F. W., 306
 Charnley, J., 364
 Chayen, M. S., 78
 Chesterman, J. J., 209
 Chikianco, P. S., 207
 Christie, H. K., 332
 Ciccone, R., 187
 Clark, B. B., 378
 Clark, F. H., 98
 Clarke, M., 10
 Clay, C. G., 414
 Clemmons, H. M., 157
 Cleveland, M., 167, 186, 240
 Clifton, E. E., 339, 357
 Clough, R. E., 187
 Coe, H. E., 412
 Cohen, A., 74
 Cohen, S. M., 207
 Cohn, G. M., 397
 Cohn, M. L., 34
 Cole, W. H., 110
 Coleman, H. M., 174, 307
 Coles, W. C., 206
 Coley, B. L., 205, 206
 Collins, D. A., 397
 Collins, D. H., 66
 Collis, E., 131
 Colonna, P. C., 302, 392
 Colson, G. M., 207
 Commons, R. R., 399
 Conklin, S. D., 28
 Conran, W. R., 210
 Constant, G. A., 211
 Cook, W. C., 238
 Cooksey, R. S., 115
 Coonse, G. K., 183
 Cooper, I. S., 126
 Cope, O., 209
 Cornell, V. H., 206
 Corper, H. J., 34
 Coss, J. A. Jr., 76
 Coventry, M. B., 36, 47, 305
 Coverstone, J. C., 59, 212
 Cowan, J. C., 59
 Craft, A. W. J., 367

Craig, J. D., 261, 367
 Grego, C. J. Jr., 2
 Crisp, E. J., 247, 262
 Cruise, J. S., 35
 Crutchfield, W. G., 184
 Culbertson, W. R., 400
 Cullen, C. H., 140, 142, 144
 Cullen, W. G., 415
 Cummings, M. C., 399
 Curry, G. J., 372
 Guthbert, J. B., 352

Dalgarno, M., 37, 47
 Dallenmagne, M. J., 388
 Dameshek, W., 382
 Dauer, C. C., 101
 Davis, A. G., 185
 Davis, C. N., 50
 Davis, D., 69
 Davis, O. L., 388
 Dawson, R. L. G., 349
 Day, A. J. W., 391
 DeBruyn, P. P. H., 390
 Dedichen, J., 335
 Dehlinger, K. R., 49
 Delorme, T. L., 116
 Delory, G. E., 396
 De Los Santos, 205
 DeMere, M., 380
 Denham, R. H., 294
 Dennison, W. M., 43
 Denny-Brown, D., 149, 316
 DePalma, A. F., 337
 DesMarais, M. H. L., 65, 67
 D'Esopo, N. D., 35
 DeStefano, G. A., 210
 Detro, J. C., 346
 DeVito, A. T., 15
 Dewar, F. P., 162
 Dickson, D. D., 210, 350
 Dickson, F. D., 97
 Dickson, J. A., 202
 Dickson, R. W., 207
 Diddle, A. W., 131
 Dill, J. L., 210
 Dittrich, D., 382
 Doan, C. A., 399
 Dobson, J., 39
 Dockerty, M. B., 211
 Donald, J. M., 337

Doerner, A. A., 35
 Dorinson, S. M., 381
 Dott, N. M., 37, 257
 Dotter, W. E., 358
 Douglas, B., 354
 Doupe, J., 140, 144
 Douthwaite, A. H., 58, 67
 Downing, F. H., 372
 Doyle, J. B., 357
 Draznin, S. Z., 280
 Dremer, M., 101
 Drew, A. L., 415
 Drewyer, G. E., 75
 Dubbs, A. W., 74
 Dugan, R. J., 109
 Duncan, J. M., 347
 Dunn, J. H., 59
 Durbin, F. G., 225

Eagle, H. R., 34
 Eaton, L. M., 136
 Eberle, F. S., 368
 Echlin, F., 141
 Edmonds, H. W., 412
 Edstrom, G., 66
 Edwards, P. M., 125
 Edwards, W. M., 98
 Eggers, G. W. N., 374
 Ehrenfeld, E. N., 49
 Elam, J. O., 111
 Elgenmark, O., 20
 Ellis, J. T., 172
 Ellman, P., 59, 65
 English, R. H., 263
 Enneking, W. F., 390
 Enyart, J. L., 161
 Esquera-Gomez, G., 51
 Evans, F. G., 391
 Evans, H. H., 37, 47, 398
 Eyre-Brook, A. L., 325

Fahlstrom, O. I., 368
 Fairbank, H. A. T., 22, 23, 27
 Fairbank, T. J., 305, 331
 Falconer, M. A., 253
 Faloon, W. W., 400
 Fan, K., 207
 Fang, H. C., 65
 Farber, S. M., 34

Farrow, R. C., 199
 Fashena, G. J., 210
 Fauteux, M., 358
 Fay, T., 133
 Feindel, W. H., 275
 Feldman, W. H., 34
 Feltner, J. B., 313
 Ferguson, C., 377
 Ferguson, T., 59
 Feuchtwanger, J. L., 36
 Fical, A., 320
 Fields, A., 333
 Finkler, R. S., 397
 Fischer, A. E., 122
 Fischer, C. J., 396, 397
 Fischer, F. J., 349
 Fischer, K. A., 285
 Fischl, A. A., 210
 Fishbein, W. I., 96
 Fisher, R. G., 209
 Fitzgerald, F. P., 169, 293
 Fitzgerald, P., 313
 Fletcher, E., 77
 Flink, E. B., 396
 Florman, A. L., 62
 Follis, C. G., 183
 Forbes, A. P., 72
 Ford, W. J., 74
 Forster, F. M., 391
 Fosdick, L. S., 389
 Foster, S. E., 25
 Foster, W. K., 187
 Fourman, L. P. H., 398
 Fox, K. W., 15
 Fox, M. J., 105, 108
 Fraenkel, G. J., 180
 Francis, T. Jr., 101
 Frankel, C. J., 3
 Freedman, H., 391
 Friedman, H. H., 76, 144, 340
 Freidwald, W. F., 101
 Freireich, K., 210
 Frenette, U., 320
 Freudenthal, W., 210
 Freyberg, R. H., 164
 Friberg, S., 244, 260, 283
 Friedenber, Z., 260
 Friedland, C. K., 392
 Friedman, H. H., 76

Fulcher, O. H., 373
 Fuller, R., 21
 Fun-Yong Khoo, 207
 Funsten, R. V., 161
 Furlong, M. B., 98
 Furste, W. L., 400

 Gale, A. H., 97
 Gallagher, J. R., 185, 367
 Gallagher, J. T. F., 172
 Gallie, W. E., 319, 326
 Gandy, J. R., 265
 Garber, C. Z., 389
 Gardner, E. D., 272, 302, 324
 Gariepy, R., 50
 Geckler, E. O., 235
 Geib, M. C., 71
 George, I. L., 165, 170
 Gervis, W. H., 355
 Geshelin, H., 69
 Ghormley, R. K., 47, 201, 305
 Giannestras, N. J., 327
 Giannini, M. J., 11
 Gibson, A., 314, 379
 Gifford, H., 109
 Gilbert, J. A., 400
 Gill, A. B., 2
 Gill, G. G., 351
 Gilmore, C. M., 146
 Ginde, R. G., 271
 Glick, H., 66
 Godfrey, M. F., 66
 Goetz, F. C., 273
 Gold, A. M., 317
 Goldberg, D., 163
 Goldenberg, R. R., 7
 Goldfain, E., 66
 Goldman, J., 74
 Goldstein, H. M., 62
 Goldstein, L. A., 315
 Goldstein, N., 112
 Goldstein, R., 16
 Golseth, J. G., 116
 Goodman, E. N., 143
 Gordon, A., 335
 Gordon, E. J., 14, 22, 304
 Gordon, M., 63
 Gordon, R. A., 335, 414

Gordon, S., 357
 Gordon, S. D., 389
 Gorham, L. W., 400
 Gorman, R. D., 34
 Gosnell, J., 116
 Gottlieb, I., 126
 Goulding, R., 356
 Graham, F. M., 47
 Graham, J. W., 279
 Graham, W. C., 352
 Granirer, L. W., 66
 Granit, R., 144
 Grant, F. C., 260
 Grantham, E. G., 246
 Graubard, D. J., 78, 112
 Graves, D. A., 11
 Gray, C., 307
 Gray, D. J., 272
 Gray, J. E., 5
 Grayson, E. S., 133
 Green, A. F., 34
 Green, B., 75
 Green, W. T., 95, 387
 Greenberg, W. B., 11
 Greenfield, J. G., 25
 Greep, R. O., 396, 397
 Griffith, G. C., 63
 Griffith, H. R., 415
 Griffith, P. R., 70
 Griffiths, D. L., 328
 Grieve, J. W., 66
 Griggs, W. B., 414
 Griswold, R. A., 206
 Grizzard, V. T., 250
 Gryboski, J. S., 68
 Gunther, W. A., 372
 Gurd, F. B., 186
 Gurdjian, E. S., 265
 Gurewitsch, A. D., 109
 Guri, J. P., 48, 205
 Guswold, R. A., 206
 Guyton, A. C., 104
 Gwinn, R. P., 394

Haas, S. L., 20
 Hagemann, P. C., 69
 Hagay, H., 1
 Haggart, G. E., 338, 357
 Hajdu, N., 14

Hakala, E. W., 159
 Haldeman, K. O., 306
 Hales, H., 74
 Hall, R. D. M., 69
 Halonen, P. I., 70
 Halperin, M. H., 392
 Hamilton, A., 303
 Hamilton, P. E., 29
 Hammond, G., 157, 166, 168,
 215, 358
 Hamea, W. R., 228
 Hanby, J., 317
 Hanisch, C. M., 393
 Hansen, A. E., 260, 399
 Hansen, H., 368
 Hansen, H. T., 380
 Hansson, K. G., 80, 146
 Hardin, C. A., 351
 Hark, F. W., 325
 Harkness, J., 59
 Harman, J. W., 393
 Harmon, P. H., 182
 Harris, H. W., 304
 Harris, L. M., 136
 Harris, R. I., 311
 Harris, V. C. J., 208
 Harrison, C. V., 206
 Hart, M. S., 51
 Hartman, T. L., 106
 Harvey, A. M., 148, 395
 Hatcher, C. H., 205, 211
 Hauser, E. D. W., 16, 211
 Hauser, H., 358
 Havens, G. G., 368
 Hawk, G. W., 212
 Hawkins, B. L., 380
 Haythorn, S. R., 281
 Hays, A. T., 47
 Headley, N. E., 64
 Heald, C. B., 59
 Hedri, E., 180
 Hedrich, D. W., 173
 Heilbrun, N., 288
 Heimbürger, R. E., 333
 Helfet, A. J., 303
 Hellenbrandt, F. A., 382
 Helwig, F. C., 102
 Hench, P. S., 58
 Henderson, M. S., 304
 Henderson, P. H., 373

Henry, M. O., 379
 Henschke, U. K., 368
 Herman, J. W., 394
 Heroy, W. W., 143
 Herrmann, H., 394
 Herschell, W., 374
 Herz, J. R., 51, 260, 372
 Heublein, G. W., 208, 286
 Higginbotham, N. L., 205, 206
 Hill, L. C., 66
 Hilnes, S. H., 381
 Hinchey, J. J., 396
 Hines, H. M., 393
 Hinkle, G. A., 368
 Hipps, H. E., 377
 Hirsch, C., 243
 Hitchcock, H. H., 331
 Hodes, R., 117
 Hoen, T. I., 126
 Hoff-Jorgensen, E., 21
 Hoffman, B. P., 274
 Hoggarth, E., 34
 Holdsworth, F. W., 185
 Hollenberg, C., 44
 Hollis, W. J., 393
 Holmes, J., 78
 Holmes, L. P., 205
 Holoubek, J. E., 393
 Holscher, E. C., 257
 Holsti, O., 72
 Hood, G. J., 371
 Hopkins, G. S., 212
 Horn, H. A., 109
 Horn, R. C., 387
 Horstmann, D., 99
 Horwitz, M., 58, 70
 Houghton, J., 209
 Howard, C. R., 377
 Howard, L. D., 354
 Howard, R., 206
 Howarth, M. B., 271
 Howie, H., 348
 Hoyt, W. A., Jr., 379
 Hubenet, B. J., 286
 Hucherson, D. C., 265
 Fuddlestone, O. L., 116
 Huff, F. G., 146
 Hughes, E. S. R., 26, 317

Hullinghorst, R. L., 109
 Humphries, S. V., 160, 173
 Hundley, J. M., 208
 Hunsberger, W. G., 291
 Hurst, W. W., 210
 Hurt, S. P., 381
 Huss, J. H., 400
 Hutter, C. G., Jr., 46

Ilfeld, F. W., 391
 Illingworth, C. F. W., 46, 365
 Immerman, E. W., 348
 Imrie, D. T., 375
 Ingelmark, B. E., 402
 Ingersoll, R. E., 115
 Ingraham, F. D., 387
 Inman, V. T., 400
 Isaacson, A. S., 281
 Ismael, W. K., 59
 Ivins, J. C., 201

Jackson, A. E., 293
 Jackson, B. R., 395, 396
 Jackson, R., 334
 Jacobs, J. E., 275
 Jacobs, L. G., 162
 Jacobs, S., 35
 Jaffe, H. L., 211
 Jarvinen, K. H. J., 70
 Jebens, E. H., 6
 Jefferson, G., 335
 Jerre, T., 287
 Jerry, L., 285
 Johnson, A., 65
 Johnson, G., 208
 Johnson, L. C., 394
 Johnson, M. A. Jr., 164
 Johnson, R. H., 382
 Johnston, W. W., 398
 Jonas, A. F. Jr., 338
 Jones, A., 97
 Jones, A. E., 61
 Jones, A. R., 314
 Jones, E. D., 392
 Jones, G. B., 401
 Jones, H. T., 219
 Jones, H. W., 206

Jones, P. A., 210
 Jönsson, G., 208
 Jorio, F., 39
 Joseph, N. R., 393
 Joynt, G. H. C., 205
 Judovich, B. D., 337
 Juers, E. H., 327

Kabat, H., 150
 Kalbak, K., 71
 Kanavel, A. B., 350
 Kaplan, A., 237
 Kaplan, E. B., 287, 311, 387, 392
 Karlen, A., 296
 Katz, B., 144
 Katz, T., 163
 Kauntze, R., 14
 Kauffman, R. R., 210
 Kaye, B. B., 176
 Keen, W. W., 137, 140
 Kehoe, J. L., 109
 Kehoe, M. B., 107
 Keiser, R. P., 97
 Kelleher, W. H., 99
 Kelly, L. C., 58
 Kelly, M., 64
 Kelso, L. E., 382
 Kemp, C. R., 393
 Kendrick, J. I., 210
 Keplan, E., 393
 Kersley, G. D., 70
 Kersley, G. D., 65
 Kessel, A. W. L., 208, 261
 Kessler, H. H., 315, 368
 Kesson, C. M., 24
 Kestler, O. C., 398
 Key, J. A., 182
 Keyes, E. J., 372
 Khoo, F., 207
 Kidner, F. C., 264
 Kidney, J. G., 35
 Kimmelstiel, P., 313
 Kinard, F. W., 395
 Kincaid, G. F., 36
 King, E. B., 221
 King, E. J., 396
 Kinsella, R. A., 66
 Kirby, C. K., 49
 Kirgis, H. D., 336, 372
 Kirk, E. J., 395, 396

Kirklin J. W., 353
 Kistler, P. M., 80
 Kitchen, I. D., 160
 Kleinberg, S., 229
 Kleinsasser, L. J., 393
 Klemperer, P., 63
 Klimek, J. W., 401
 Knapp, M. E., 105, 116
 Knight, G. C., 269
 Knight, R. A., 133
 Knott, M., 150
 Knudson, A. B. C., 376
 Knutsson, F., 272, 327
 Kobayashi, C. K., 109
 Kohn, E. E., 108
 Koloski, E. L., 28
 Korvin, H. G., 279
 Kottke, F. J., 116
 Koucky, J. D., 329
 Kovacs, J., 78
 Kovacs, R., 145
 Krahll, V. E., 325
 Krehl, W. A., 398
 Kresky, B., 81
 Krida, A., 59
 Kridelbaugh, W. W., 27
 Krueger, F. J., 35, 175, 319
 Kuffler, S. W., 124
 Kuhn, R. A., 126
 Kurtin, A., 318
 Kurulkar, L. N., 271
 Kuzell, W. C., 67

Lahiri, K. D., 62
 Lahz, J. R., 356
 Lamphier, T. A., 50
 Landsmeer, J. M. F., 325
 Lange, M., 176
 Langley, W. D., 209
 Langohr, J. L., 394
 Langston, H. H., 295
 Lapidus, P. W., 207, 311
 Larson, C. B., 331
 Last, R. J., 302
 Latiolais, S. G., 172
 Lauber, H. C., 25
 Law, W. A., 81, 291
 Lawrence, J. H., 205
 Leavitt, H. L., 33
 Lebo, L., 410

Lee, C., 207
 Lefevre, W. I., 330
 Leftwich, W. B., 148
 Leggett, B. J., 388
 Lehman, O., 198
 Leibolt, F. L., 350
 Liebow, A. A., 400
 Leksell, L., 144
 Lemesurier, A. B., 298, 326
 L'Engle, C. S., Jr., 39
 Leonard, M. H., 316
 Lepine, P. R., 102
 Lerner, H. H., 29
 Leslie, M., 208
 Leslie, W. D., 98
 Leatherman, K. D., 285
 LeVay, D., 333
 Levens, A. S., 400
 Leveuf, J., 4, 44
 Levi, D., 338
 Levine, J., 304
 Levy, B. M., 398
 Levy, D., Jr., 164
 Lewen, P., 110
 Lewis, G. B., 178
 Lexer, E., 354
 Lichtenstein, L., 211
 Liebow, A. A., 400
 Lincoln, E. M., 34
 Lindblom, K., 255, 256
 Lindley, E. L., 69
 Linegar, C. R., 415
 Lipkin, E., 74, 79
 Lipman, M. G., 76
 Lippmann, R. K., 293
 Lipscomb, P. R., 304
 Lissner, H. R., 391
 Litman, N. N., 113
 Little, G. W. E., 242
 Littler, J. W., 351, 375
 Livingston, W. K., 140
 Loadman, J. B., 349, 379
 Lockie, L. M., 73
 Loge, J. P., 382
 Lohman, H., 350
 Loomis, L. K., 175
 Loopesko, E., 275
 Loos, R., 375
 Loring, H. S., 103

Loudon, J. B., 349
 Lounsbury, B. F., 392
 Love, F. M., 210
 Lowbeer, L., 50
 Lowman, C. L., 114
 Lowry, K. F., 378
 Lucas, L. S., 6
 Lucchesi, M., 65
 Lucchesi, O., 65
 Luckey, C. A., 210, 350
 Lugiato, P. E., 72
 Lumb, G., 209
 Lurje, A., 331
 Lyerly, J. G., 250

Mabrey, R. E., 206
 MacDonald, A., 47
 MacKinnon, W. B., 314
 MacLaughlin, E., 35
 MacLean, J. R., 8
 MacNamara, J., 112
 MacMahon, H. E., 25
 Madden, W. J., 105, 108
 Malkin, S. A. S., 33
 Millinson, F. B., 126
 Mammel, C. K., 208
 Man, T. F., de, 21
 Mann, F. C., 389
 Manning, R. A., 74
 Markkula, R. F., 368
 Marks, J. H., 349
 Marple, C. D., 393
 Marsters, R. W., 392
 Martin, A. R., 34
 Martin, B., 170
 Martin, C. G., 38
 Martin, E., 39
 Martin, P. H., 282
 Masland, H. C., 158
 Mason, M. L., 346, 347
 Mason, R. M., 331, 59
 Masters, E. W., 62
 Mathisen, A. K., 36
 Matoth, Y., 49
 Matson, D. C., 387
 Mauch, H., 368
 Maurer, E., 210

May, H., 175, 354
 Maycock, P. K. Jr., 143
 Mayer, J. H., 80, 274, 307
 Mayer, J., 398
 Mayer, L., 296
 Maxeiner, S. R., 365
 McAlpine, D., 98, 101
 McCarroll, H. R., 3, 113
 McCarter, J. C., 103
 McCauley, J. C. Jr., 82
 McCutcheon, A., 24
 McDonald, D. P., 158
 McDonald, E., 399
 McFarland, B., 11, 307
 McGaw, W. H., 302
 McGeorge, M., 253
 McKelvey, G. J., 46
 McKelvie, A. M., 389
 McKeown, E. F., 64
 McKone, B., 33
 McLaughlin, C. R., 318
 McLaughlin, H. L., 171
 McLean, G., 410
 McMurray, T. P., 304
 Mearns, R. B., 284
 Meenen, P. N., 101
 Meirowsky, E., 29
 Meredith, H. C. Jr., 136
 Mes, G. M., 243
 Meschan, I., 302
 Messer, A. A., 400
 Metcalf, J. W., 45
 Meyer, K., 72
 Meyer, O., 74
 Meyerding, H. W., 130
 Meyers, S. G., 304
 Michele, A. A., 35, 159, 175, 319
 Middleton, J. W., 69
 Milch, H., 348
 Milgram, J. E., 115
 Millar, J. D. C., 367
 Miller, A., 178
 Miller, A. D., 35
 Miller, B. L., 373
 Miller, E. S., 97
 Miller, J. W., 281

Milner, I. H., 332
 Milstein, B. B., 349
 Miniero, J. D., 349
 Mira, J. J., 46
 Mitchell, C. L., 173
 Mitchell, S. W., 137, 140
 Molter, H. A., 241
 Monticelli, G., 417
 Moon, H. D., 210, 350
 Moor, F. B., 80
 Moore, A. T., 230
 Moore, F. T., 352
 Moore, J. R., 201
 Moore, M. R., 206
 Moore, M. Jr., 304, 328
 Moore, T. R., 245
 Moorehouse, G. R., 137, 140
 Morgan, L., 11
 Morris, H. D., 365
 Morris, N., 24
 Morrison, G. M., 329
 Morse, A., 396
 Morse, L., 21
 Morse, P. W., 36
 Mottershead, S., 336
 Moyer, R. E., 35
 Mulligan, R. M., 398
 Mumford, E. B., 177
 Munro, H. N., 399
 Murray, L. H., 109
 Musgrove, A. H., 127
 Mustard, W. T., 115
 Myers, W. K., 69

Nach, R. L., 350
 Nachlas, I. W., 9
 Maclerio, E. A., 272
 Naden, J. R., 292
 Nalls, W. L., 35
 Nauta, W. J. H., 324
 Neer, C. S., 171
 Nelson, M. M., 37, 47, 398
 Neufeld, A. J., 329
 Neviasser, J. S., 328
 Newcomb, W. J., 241, 315

Newman, P. H., 358
 Nichol, A. A. M., 59
 Nichols, G. B., 67
 Nicholas, J. S., 394
 Nicholson, D. P., 78, 59
 Nieto Cano, G., 351
 Nissen, K. I., 38, 100, 313
 Noble, J. A., 276
 Norcross, B. M., 73
 Norcross, J. R., 37
 Norley, T., 36, 305
 Norwich, I., 330
 Novotny, H., 74
 Nunziata, A., 235
 Nygaard, K. K., 356

Oberhill, H. R., 333
 O'Brien, R. M., 46
 Oldberg, E., 262
 Oldfield, M. C., 354
 Olsen, A. K., 143
 Orbach, E. J., 376
 Orton, R. H., 414
 Ortved, W. E., 205
 Osborne, S. L., 80, 116
 Osmond-Clark, H., 327
 Otten, C., 177

Paff, G. H., 389
 Page, M. A., 28
 Palmer, I., 177, 325
 Paparella-Treccia, R., 307, 417
 Pardee, M. L., 307
 Parker, D. W. L., 290
 Parnell, E., 245
 Parr, L. J. A., 74
 Parsonage, M. J., 147
 Paul, H. E., 392
 Paul, M. F., 392
 Paul, W. D., 393
 Pautrier, L. M., 210
 Pava, J. R., 372
 Peabody, C. W., 305
 Pearson, C., 316
 Pedersen, H. H., 391
 Pendse, R. D., 145
 Pehnal, G. F., 315

Penner, L. R., 101
 Perlman, M. W., 15, 22
 Perlman, H. B., 210
 Perrin, M. B., 135
 Perry, C. B., 62
 Peterman, E. A., 63
 Peters, G. S., 338
 Pfeutze, K. H., 34, 35
 Phalen, G. S., 352
 Phelps, W. M., 131
 Phemister, D. B., 197, 205, 356
 Pickard, M. S., 66
 Pilcher, E. S., 349
 Pinckney, M. M., 73, 74, 76
 Pincock, D. F., 372
 Platt, H., 223
 Plewes, L. W., 376
 Pohl, J. F., 113
 Pollack, L. J., 106, 128
 Pomerantz, R. B., 339
 Pomeranz, M. M., 400
 Ponseti, I., 209, 283
 Poppe, J. K., 271
 Portal, A., 21
 Potter, E. L., 212
 Potter, J. M., 250
 Pratt, G. H., 380
 Preston, F. S., 48
 Price, L. W., 65, 209
 Pridie, K. H., 314
 Puckey, S., 37, 47
 Pulvertaft, R. G., 353
 Pyle, M. M., 34, 36

Quigley, T. B., 304, 375
 Quintin, T. J., 62

Rachmilewitz, M., 392
 Raffel, S., 103
 Ragan, C., 72
 Railton, S. V., 348
 Rampoldi, A., 7
 Raney, A. A., 258, 334, 373
 Raney, R. B., 258, 334, 373
 Rank, B. K., 355
 Rankin, J. O., 200
 Ransohoff, N. S., 111

Rappaport, B., 112
 Ratliff, A. H. C., 349
 Raven, C. P., 388
 Raven, R. W., 65
 Read, W. A., 70
 Reed, A. R., 336, 372
 Rees, S. E., 67
 Reeves, R. J., 210
 Reginster, A., 34
 Reiners, C. R., 387
 Reisenman, F. R., 130
 Reissman, S., 212
 Reno, J. H., 182
 Rexed, B., 256
 Reynolds, F. C., 47
 Richardson, J. E., 327
 Richman, R. M., 187
 Riddel, A. G., 349
 Ries, L., 375
 Rinzler, S. H., 148
 Riordan, D. C., 352
 Rise, W. S., 338
 Ripstein, C. B., 157, 358
 Riser, W. J. Jr., 209
 Risley, H. A., 151
 Rittenberg, D., 399
 Ritter, H. H., 78
 Ritvo, M., 69
 Rizzo, P. D., 198
 Roaf, R., 127
 Robertson, J. E., 96
 Robertson, J. W., 387
 Robinson, D., 205
 Robinson, W. D., 71
 Roche, M. B., 63, 243
 Rodholm, A. K., 356
 Rosenberg, D., 112
 Rosenberg, M. L., 48
 Rosenblum, H., 64
 Rosenow, E. C., 102
 Rosin, A., 392
 Ross, D., 20
 Ross, S. T., 212
 Rossignol, J. C., 332
 Routti, O., 72
 Rowbotham, G. F., 248
 Robertson, G. W., 387
 Roy, L. P., 207

Royster, M. P., 49
 Rozansky, R., 49
 Rubin, L. R., 387
 Ruch, M. K., 352
 Rugg-Gunn, M. A., 22
 Russell, B., 75, 317
 Russell, C. D., 375
 Russell, H. S., 68
 Russell, W. R., 97
 Ryan, C. A., 272
 Ryle, J. C., 100

 Sacasa, C. F., 69
 Sadek, E., 286
 St. James, R., 131
 Salem, E. P., 240
 Sallick, M. A., 319
 Salzman, F. A., 207
 Sampson, D. A., 348
 Samson, J. E., 306
 Samson, A., 285
 Sanchis-Olmos, V., 33
 Sanders, E. M., 147
 Sandison, C., 348
 Sante, L. R., 207
 Savage, O., 59
 Saxton, G. D., 36
 Scanlan, R. L., 69
 Scales, J. T., 375
 Schaefer, J. E., 207
 Schechter, N., 14, 22, 304
 Schiller, M. A., 396
 Schlesinger, E. B., 127, 415
 Schlesinger, P. T., 208, 380
 Schlaepfer, K., 380
 Schmitt, O. H., 144
 Schneider, G. T., 136
 Schnute, W. J., 320
 Schorr, S., 212
 Schram, W. R., 389
 Schroder, M., 355
 Schroff, J., 210
 Schukmecht, H. F., 210
 Schulenberg, C. A. R., 356
 Schultz, E. C., 184
 Schulz, M. D., 206
 Schwab, R. S., 116

Schwartz, R. P., 125
 Schwartzman, J. R., 2
 Scobey, R. R., 102
 Scott, G. L., 68
 Scott, J. C., 349
 Scott, S., 48
 Scott, W. F., 209
 Scuderi, C., 186, 199, 379
 Scudese, V. A., 273
 Scully, F. J., 74
 Sear, H. R., 13
 Seddon, H. J., 111, 129
 Seid, B., 61
 Self, E. B., 44
 Senear, F. E., 70
 Sensenig, E. C., 388
 Seth-Smith, D. W., 66
 Shaber, H., 116
 Shaffer, J. O., 70
 Shapiro, L. B., 65
 Shapiro, R. N., 387
 Shaw, A. B., 185
 Shaw, M. H., 318
 Shaw, R. S., 257
 Shellito, J. G., 211
 Sherman, I. C., 395
 Sherman, M. S., 391
 Sheppard, W. B., 255
 Shipp, F. L., 47
 Shockman, R., 206
 Short, D. W., 211
 Shumacker, H. B. Jr., 137, 138, 139
 Shuman, H. H., 21
 Siegel, S., 116
 Silberberg, M., 398
 Silberstein, H. E., 400
 Silverman, F. N., 207
 Simmonds, F. A., 295
 Simmons, C. C., 48
 Simpson, N. R. W., 72
 Sims, M. M., 378
 Sinclair, D. C., 275
 Sinberg, S. E., 185
 Singer, K., 280
 Skoglund, C. R., 144
 Skowlund, H. V., 382
 Slocum, H. C., 410
 Smedal, M. I., 207
 Smillie, I. S., 303
 Smith, E., 112
 Smith-Petersen, M. N., 291
 Smyth, F. S., 25
 Snapper, I., 209
 Snethan, H. J., 368
 Snow, W. G., 67
 Soderberg, B. N., 380
 Sommerville, E. W., 38
 Soto-Hall, R., 306
 Spear, G. E., 70
 Speigel, I. J., 138
 Spiesman, I. G., 207
 Spinelli, V. A., 47
 Spira, E., 331
 Spitzer, N., 76, 144, 340
 Spitzer, R., 209
 Sponsel, K. H., 215
 Spray, G. H., 398
 Spriggs, J. B., 181, 263
 Spurling, R. G., 246
 Stack, J. K., 353
 Stahl, F., 281
 Stanbury, J. B., 394
 Starr, E. E., 317
 Stearns, W. H., 34
 Stebbins, 353
 Stecher, R. M., 69, 358
 Steele, J. M., 66
 Steenken, W. Jr., 35
 Stein, I., 372
 Steinbach, H. B., 394
 Steinberg, C. L., 61
 Steinbrocker, O., 144, 76, 340
 Steindler, A., 1
 Steinman, C., 389
 Stengel, E., 80
 Stenhouse, D., 208
 Stevens, A. E., 9
 Stevenson, J. W., 161
 Stevenson, E. M., 338
 Stokes, H., 209
 Strange, T. B., 160
 Strauss, E., 100
 Stricker, F. L., 398
 Strickland, E. L., 368
 Strug, L. H., 159
 Stubbins, S. G., 354
 Stuck, W. G., 174, 229, 289, 374
 Sugar, S. J., 50

Julamaa, M., 45
Sulon, E., 37, 45
Svartz, N., 74
Swenson, S. L., 22, 158
Swenson, S. A., 365
Sydow, G. Von, 21

Tabrah, F. L., 412
Tanner, H. A., 103
Tanzer, R. C., 348, 351
Taylor, R. A., 335
Taylor, J. D., 392
Taylor, L., 64
Tegner, W. S., 73
Teigen, B. S., 116
Telford, E. D., 336
Tenbrinck, M. S., 95
Terhune, S. R., 375
Thiele, G. H., 238
Threadgill, F. D., 138
Tho, A., 66
Thomas, C. G. Jr., 353
Thompson, A. R., 376
Thompson, F. R., 167, 240
Thompson, J. E. M., 346
Thompson, V. P., 391
Tobias, C. A., 71
Tobias, N., 318
Tobin, W. J., 375
Toland, J. J. III, 107
Toone, E. C. Jr., 76
Torgerson, J., 271
Toumey, J. W., 47, 141
Townsley, W., 388
Traeger, C. W., 226
Travell, J., 148
Trevor, D., 160
Troncelliti, E. T., 135
Trusta, J., 43, 45
Trunnell, J. B., 161
Tucker, W. E., 313
Tucker, F. R., 44
Tumilty, P. A., 148
Tureman, G. R. Jr., 368
Turner, J. W. A., 147
Turner, R. H., 144
Turner, W. W., 243

Umansky, A. L., 184
Unger, H., 212
Unger, P. W., 66
Upjohn, R. H., 132, 138
Upshaw, J. E., 38
Urist, M. R., 165, 375
Ustvedt, H. J., 210

Valentine, M., 68
Van Demark, R. E., 347, 353, 349
Van Gorder, G. W., 169
Vandmark, W. E., 28
Van Nes, C. P., 367
Varadarajan, M. S., 51
Vasko, J. R., 367
Vastine, J. H. II, 14, 388
Vastine, M. F., 14, 388
Vaughan-Jackson, O. J., 356
Venable, C. S., 374
Vergara, S. E., 397
Vest, S. A., 48

~~████████████████████~~
Viets, H. R., 134
Virkkunen, M., 76
Vitt, R. J., 175
Vuori, E. E., 45

Wade, B. G., 69
Wagner, C. J., 198
Wagner, L. C., 303
Wagner, M. L., 381
Wahl, S., 168
Waine, H., 68, 71
Wakefield, A. R., 355
Walker, H. G., 35
Walker, P. J., 80
Wallgren, A. J., 33
Walsh, F. P., 305
Ward, G. E., 377
Warren, R. F., 389
Warren, S., 206, 208
Warrick, C. K., 327
Washburn, S. L., 388
Waspe, 170
Watkins, A. L., 116
Watkins, M., 318

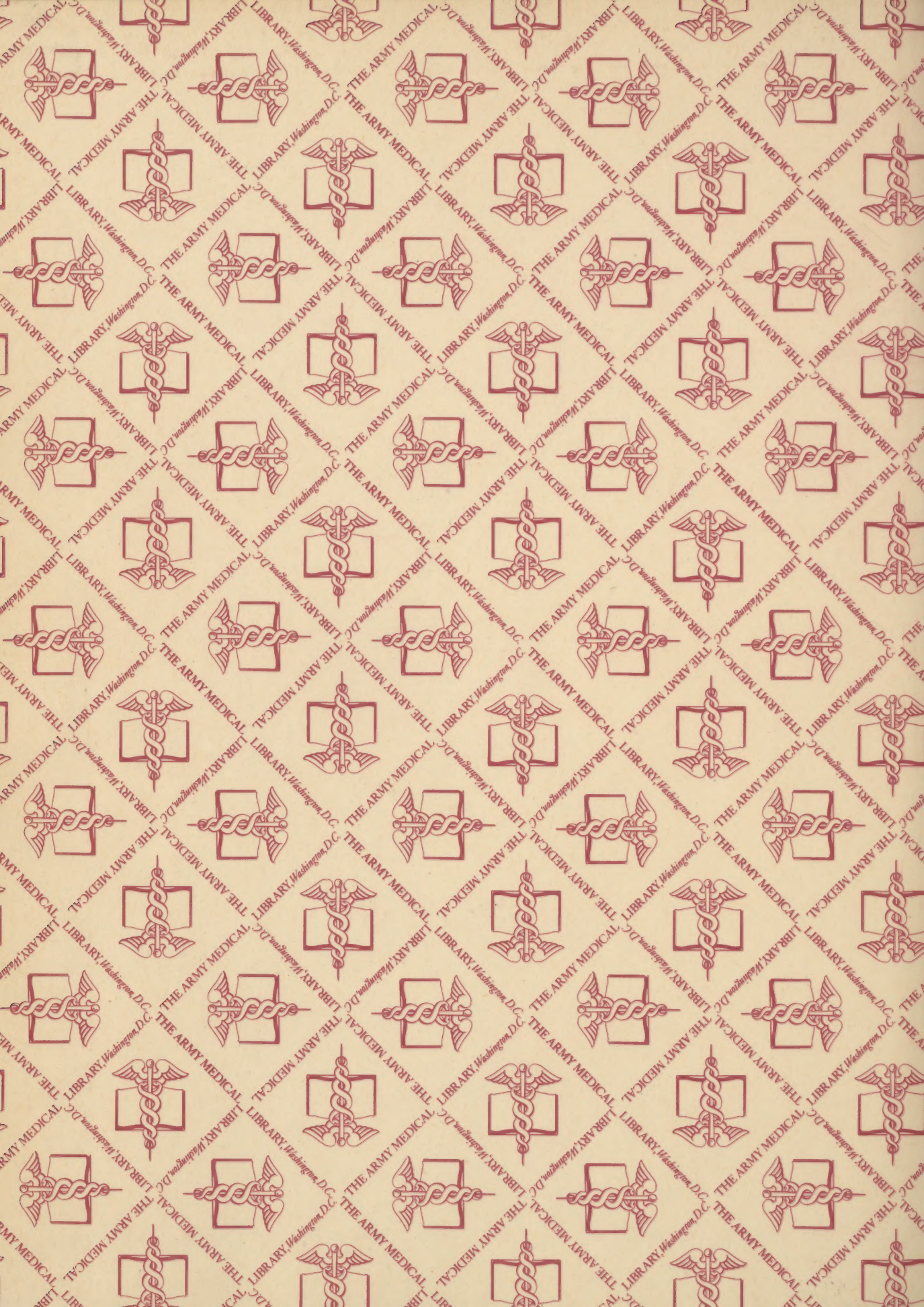
- Watson-Jones, R., 326
 Waugh, G., 77
 Waugh, W. G., 59
 Waugh, R. L., 181, 347
 Waxman, A., 69
 Way, C. B., 26
 Weaver, R. M., 210
 Weber, R. P., 65, 25
 Webster, J. E., 265
 Weckesser, E. C., 351
 Weger, A. T., 368
 Weidenthal, C. M., 109
 Weigner, W. C., 147
 Weil, I. F., 29
 Weinstein, L., 106
 Weisel, W., 381
 Weiss, P., 395
 Welch, C. S., 401
 Welch, J. H., 124
 Wells, J. C., 187
 Wenner, H. A., 103
 West, E. F., 235
 Westerborn, A., 178
 Whalley, N., 248
 Wheat, H. R., 375
 Wheeler, W. E., 98
 Wheelock, M. C., 205
 White, A. R. V., 62
 White, E. H., 161
 White, J. C., 143
 White, W. A., 379
 Wiese, H. R., 399
 Widen, A., 325
 Wiggins, H. E., 178
 Wiggers, R. F., 61
 Wigley, J. E. M., 61
 Wilbur, R. C., 49
 Wilkins, R. W., 392
 Wilkinson, F. R., 44
 Willcox, A., 207
 Willcox, R. R., 61
 Williams, D. I. G., 76, 77
 Willner, P., 355
 Wilson, C. D., 259
 Wilson, C. L., 401
 Wilson, J. C. Jr., 50, 158
 Wilson, J. L., 111
 Wilson, M. J., 207
 Wilson, W. J., 5
 Wiltberger, B. R., 173
 Windham, S. W., 172
 Windholz, F., 25
 Winkler, H., 313, 176
 Winter, E. F., 357
 Wise, C. S., 393
 Wise, R. A., 367
 Wiseman, R. K., 399
 Wishart, J., 38
 Wissing, E., 209
 Wolfson, S. A., 68, 378
 Wolgamot, J. C., 281
 Wolinsky, E., 34
 Wolman, B., 5
 Woltman, H. W., 108
 Wood, C. F., 115
 Wood, F. J., 314
 Wood, R. V., 377
 Wood, W. G., 415
 Woodbine, M., 34
 Woodruff, J. B. Jr., 210
 Woods, R. P., 395
 Wooley, P. V., 208
 Woolf, D. L., 21
 Wright, C. M. F., 157
 Wright, H. P., 75, 381
 Wright, H. R., 71
 Wright, N. E., 187
 Wulp, G. A., 73
 Wyburn, G. M., 391
 Wydro, R. A., 371
 Wyman, A. C., 27
 Wyman, S. M., 48, 209
 Yancey, A. G., 347
 Ytrehus, O., 223
 Yontef, R., 318
 Young, H. H., 36, 81, 263
 Younger, F., 398
 Zaepfel, F., 47

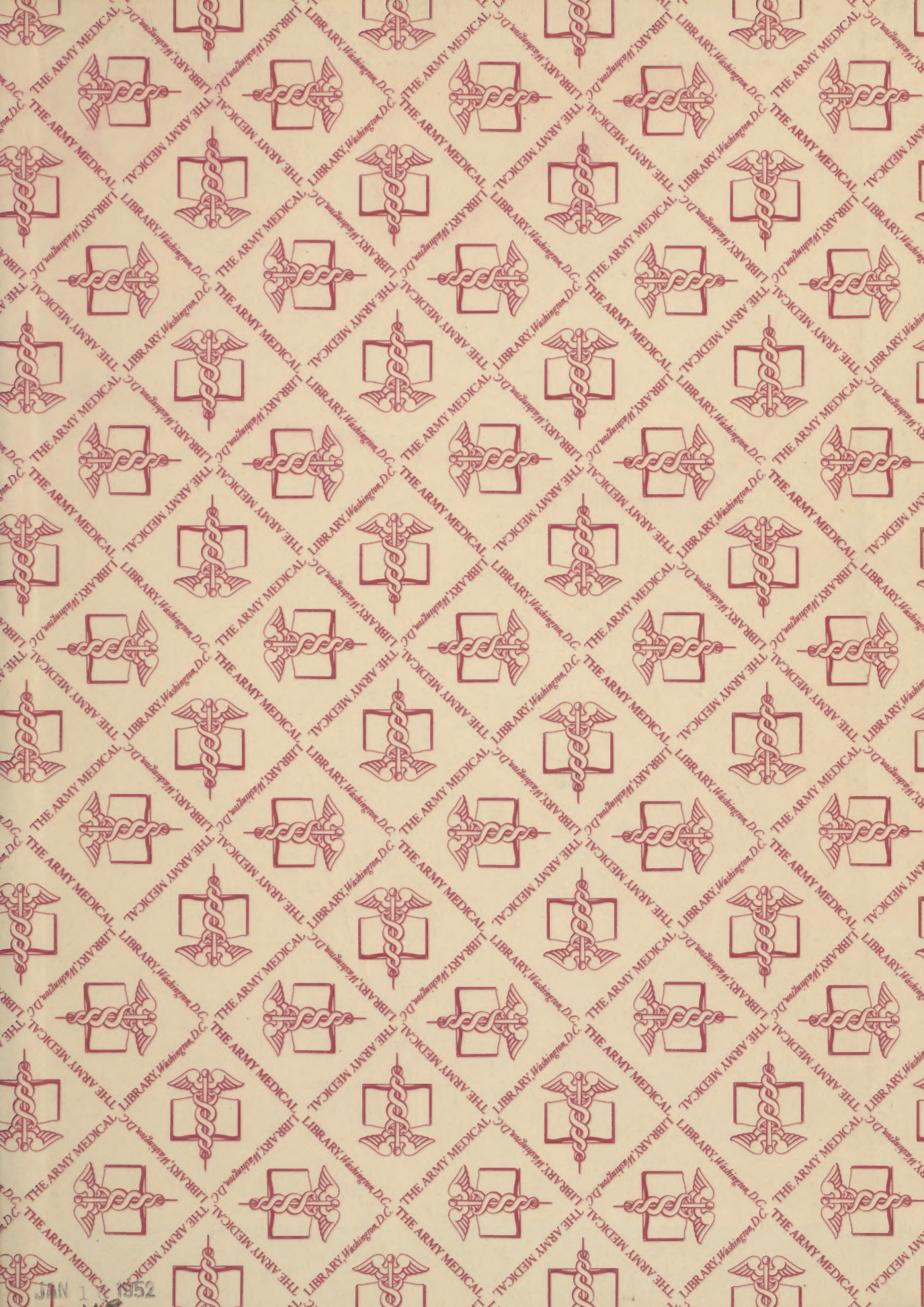
Zadek, E., 286
Zadek, I., 280, 317
Zadick, F. R., 327
Zarrow, M. X., 397

Zeben, W. Van, 22
Zeldenrust, J., 388
Zimmerman, A. J., 415
Zuckerbrod, M., 66

Zuelzer, W. A., 374

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